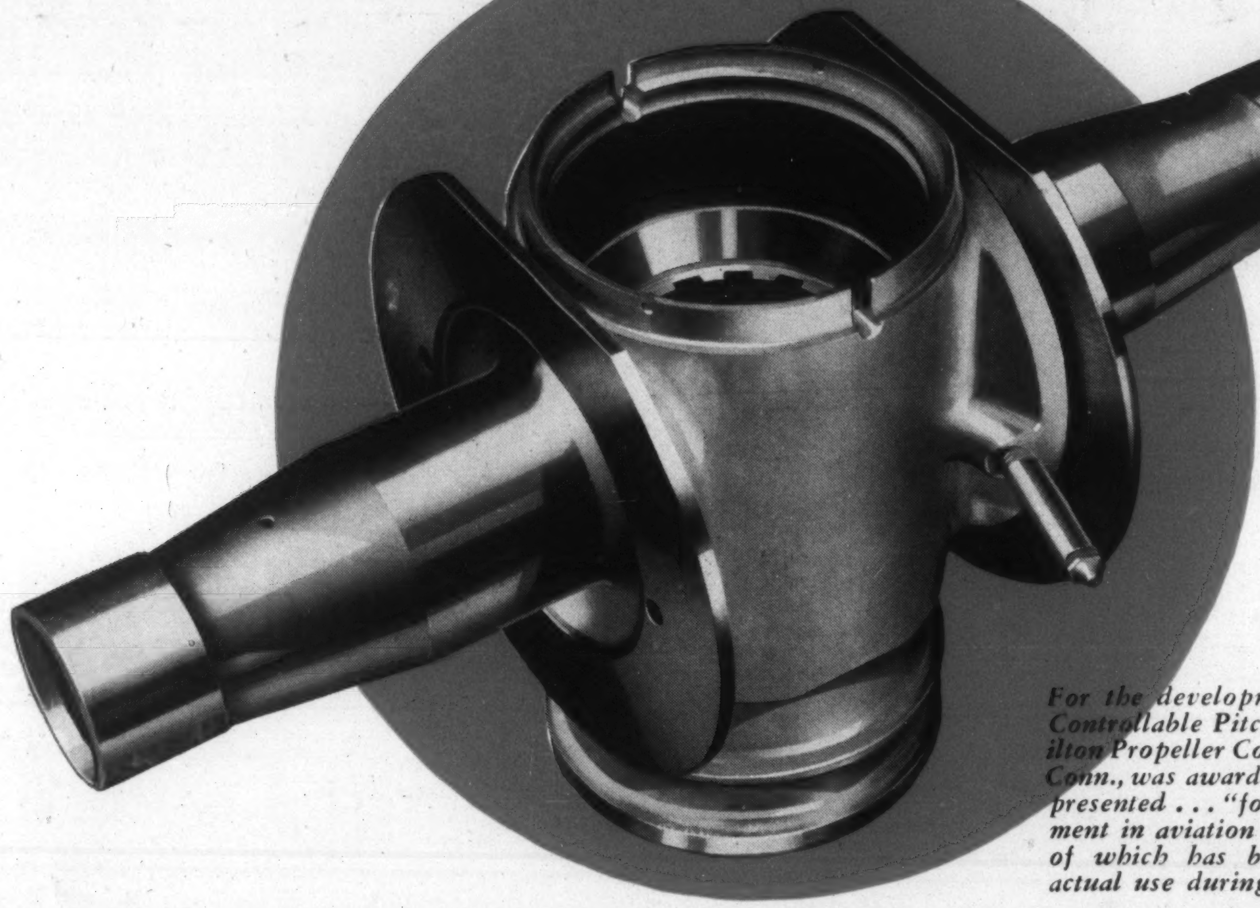
NOVEMBER, 1934 NOV 19 1934

METALS & ALLOYS

The Magazine of Metallurgical Engineering

PRODUCTION • FABRICATION • TREATMENT • APPLICATION

Current Metallurgical Abstracts



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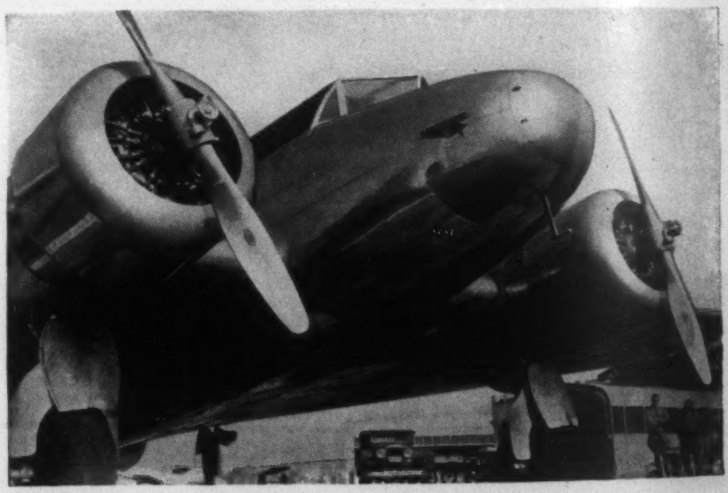

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The Magazine of Metallurgical Engineering

Production • Fabrication • Treatment • Application

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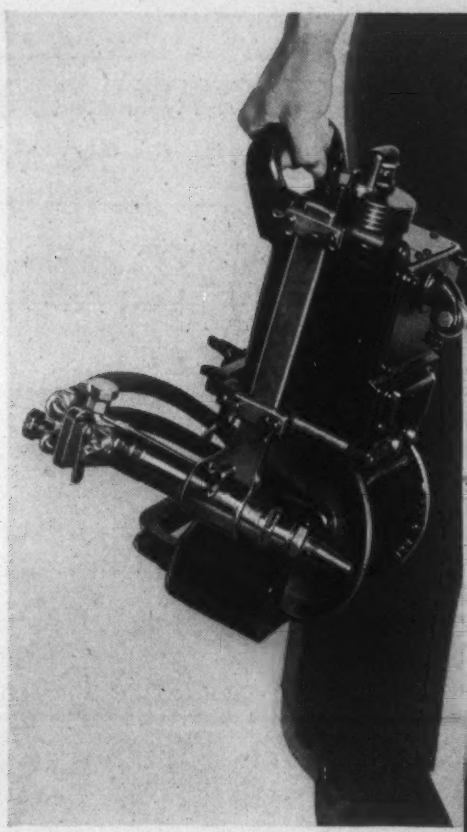

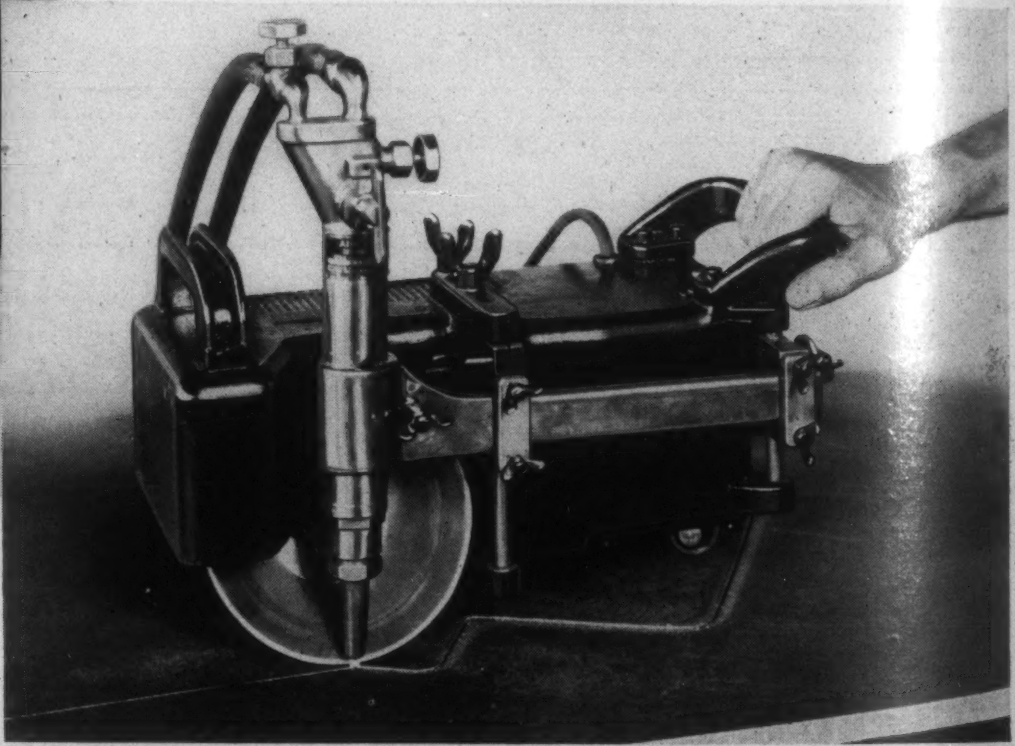

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PIONEERS IN DEVELOPING OXYACETYLENE CUTTING PRACTICE AND MACHINES

HIGHLIGHTS

by H. W. GILLETT

DO YOU want to know what metallurgical engineers are saying, the world over? Look in the Current Metallurgical Abstracts. Here are some of the points covered by authors whose articles are abstracted in this issue.

Laboratory Tests vs Service

Houdremont (page MA 538 R 1) says that high temperature oxidation and corrosion by sulphur gases is a complex thing and that lab. tests don't always agree with service. Did we ever hear that comment before in other connections? Anyhow, recognition of complexity is the first step toward separate evaluation of the component factors, and it's a relief to have tests viewed critically rather than put forth as panaceas.

Service Failures and Impact Resistance

Grotts (page MA 536 R 2) points out that service failures often arise from low impact resistance of steel castings, but that it is possible to do something about improvement of impact values. It's refreshing to have foundrymen realize, discuss, and remedy short-comings of their product, and good sense, too, for the output of producers who pay no attention to such matters, tends to blacken the eye of the whole industry.

Large Forgings

According to a Russian publication (page MA 515 L 1) 30 ton forgings, though containing but 0.006 to 0.012% S nevertheless showed sulphur segregation and low ductility in the core of the forging. One wonders if some other factors than the S were not involved.

More About Wear

Other discussions of wear problems are by Eilender and co-workers (page MA 539 L 1) Heller (page MA 536 R 1) Automobile Engineer (page MA 540 L 1) and Baudoin (page MA 542 R 9) all of which testify to the complexity of the wear problem.

Fatigue

We like the abstract of Kuhl's article (page MA 531 L 8) where the abstractor and the section editor run up a red flag because they disagree.

Intercrystalline Cracking

Singleton (page MA 534 R 7) points out that coarse grains of unequal size give rise to uneven distribution of strain and this results in intercrystalline cracking. He's talking about lead but the idea might have a wider application.

Fatigue of Duralumin

Fatigue of duralumin has attention from Sutton and Taylor (page MA 534 R 9) who find a lowering of endurance resistance by caustic pickling followed by acid amounting to some 30%, while a certain procedure of acid pickling only, has practically no effect. There must be a notch-propagation effect, for machining of the NaOH-pickled layer removed the damage.

Tube Making

Polushkin (page MA 515 R 3) describes a tube-making process said to allow huge reductions.

It's Valuable to Show Up Things That Aren't So

The "wear-oxidation" findings of Fink have been quoted in textbooks by high authorities. Now come Rosenberg and Jordan of the National Bureau of Standards (page MA 540 L 2) to show that Fink's dope is either in error or that the generalizations people are drawing from that dope are far too broad. It's tough enough to try to figure out the whys and wherefores of wear without having faulty premises to complicate the situation further.

Abstractors have to report what authors say, but what the authors say is not always to be taken without qualification—Bassett's discussion of boiler safety plugs (page MA 538 L 1) advocates cold pouring of the tin filling, though the Bureau of Standards several years ago showed that with cold pouring the plug might easily be loose in the casing. To avoid this the Steamboat Inspection Service raised the permissible copper pick-up so as to allow hotter pouring. The variation in melting point is a very minor affair of no engineering importance. A loose filling is of real importance.

Another example of things that aren't so, broadly speaking, is the Juretzek and Sauerwald (page MA 538 L 3) finding that short-time up-step creep tests coincide with regular long-time creep tests. By chance they may coincide in a particular lot of steel, but there's plenty of definite evidence that generalization from such an observation is quite erroneous. Such generalizations are often made as a result of wishful thinking. In time those who rely on the short cuts will find plenty of steels in which the alleged relation doesn't hold and will then back water. In the meantime plenty of harm is done by spreading a false gospel to engineers.

Still another thing that probably isn't so is contained in Schönrock's (page MA 543 L 5) on fatigue strength of high tensile structural steel. The German St. 52 covers a multitude of analyses as the designation refers to tensile strength alone. There is plenty of evidence that some, at least, of the high strength steels have correspondingly high endurance limits. The author's contention that St. 37 is generally just as good for bridges may be true, we're no bridge engineer, but the argument he uses to support his contention is certainly cock-eyed.

More on Fatigue

Fatigue in non-ferrous alloys is again brought up by Macnaughtan's suggestion (page MA 534 R 10) that cracking of babbitt in a bearing may be a fatigue phenomenon.

Bearing-Lubricant-Shaft

Godfroid (page MA 535 R 1) comments that not only the bearing and the lubricant affect the coefficient friction, but so does the shaft. He thinks that the shaft should have a homogeneous structure.

Aluminum Coatings

Aluminum coatings on steel are discussed by Röhrig (page MA 527 L 1) who tells about hot-dipping, by an anonymous author in Giessereipraxis (page MA 527 L 4 who paints on a mixture of Si and an Al Si alloy for heat-resistant purposes, and by Kolke (page MA 527 L 6) who deals with ordinary Al flake, but says that for a coating for high-temperature service the flake should not have any fatty material, such as is usually used in polishing the flake, on it.

Regenerator Stove

Müller-Berghaus (page MA 520 R 1) says a Ni Cr heat resisting alloy regenerator stove is being built for a 600 ton German blast furnace.

Boric Acid in Chromium Plating

According to Weber (page MA 526 R 1) boric acid is good in a Cr-plating bath and phosphoric acid rotten.

Deep Drawing

Another effort to evaluate deep drawing properties is made by Goederitz (page MA 530 R 2) who studies the Erichsen test in some detail. He finds that proper die clearance is a function of the material being drawn.

Kuhn (page MA 532 L 4) reports still another test for showing properties of deep drawing steel, this time a magnetic one.

Cast Iron vs Steel

Le Thomas (page MA 542 L 1) remarks that in some naval engineering uses cast iron may be preferable to steel castings.

Iron Oxide in Slags

Excess lime in slags favors the formation of lime iron oxide compounds according to Salmang and Kaltenbach (page MA 512 R 1). High silica favors the formation of FeO rather than Fe_2O_3. CHH

Corrosion

You have seen movies run backward in which the pieces of a smashed car pick themselves up and assemble themselves into the original car. That is what Colin G. Fink (page MA 540 R 1) has been doing with corroded bronzes and museum pieces. VVK

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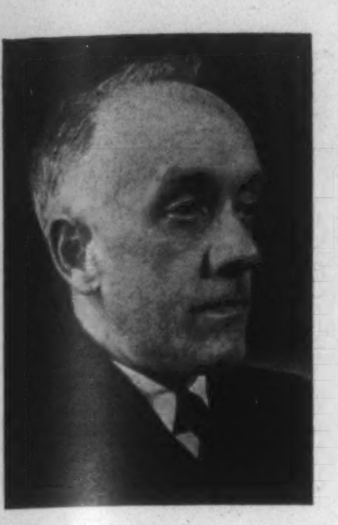

EDITORIAL COMMENT

Detective Story Metallurgy

WHETHER they be trouble-shooting jobs in the plant, or high-brow research problems, most technical metallurgical difficulties involve untangling a mass of variables in a fashion not dissimilar to the untangling of clues by Charlie Chan or Hercule Poirot. When you really have the answer, it is generally absurdly simple.

The metallurgical detective needs much the same type of mind that the best-seller detective does, ability to match a theory to the facts, to give final allegiance to no theory until all the facts fit it, and to search with patience for missing links in the chain of evidence.

Fortunately, in metallurgical matters, things do not lie, as do the characters in the books when the detective quizzes them, but to offset that, much of the experimental evidence is available only from man-written accounts which may not state all the surrounding circumstances and which are often obscured by the faulty interpretation the experimenter puts on his facts. It is just this that has led to the requirement of papers committees that experiments be recorded so that some one else can duplicate them.

The outstanding operating man and the outstanding research man are the ones who can pick out from among the maze of clues those pertinent ones that really affect the problem, and who can see through the alibis of the apparently minor things that one would not think had anything to do with the case.

Henry Marion Howe had, in supreme measure, the attributes of the great detective. Working in a time when many of the modern means of locating obscure facts were not yet available, he, nevertheless, put together what we in many cases would now consider extremely fragmentary information and drew logical deductions therefrom that have had to be changed very little when the gaps that he had to guess at were filled by quantitative data.

Reading over his Metallography of Iron and Steel the other day, we chanced upon a sentence that put in a nutshell the basic principle of a problem that a group of able metallurgists worked on for two years, before they came to agree upon exactly the answer they would have found set down for them years before by Howe, had they looked for it and understood its application.

When the evidence was not air-tight, Howe was open-minded but slow to comment himself. In regard to the amorphous theory, very active in his time, though since abandoned or vastly modified, he said, "To the fourth cause I find no objection thus far, for it seems antecedently probable, compatible with all the evidence and indeed needed to explain much of it. Of course, like every other newly enunciated hypothesis, it must be received with caution till it has been tested by experiment and discussion. If it falls, may its ruin serve the builder of a better."

Now that our freshman text books build up much of the basic metallurgical structure by means of X-ray evidence, it is amazing to see how much Howe had accomplished by the application of old-line crystallography.

With all the tools of the metallurgist and the physicist, there are still realms in which the detective's intuition has to be applied. Those things that are beyond the resolving power of the metallurgical microscope and are not detectable by X-ray methods—so sensitive for some things and so insensitive for others—such as the postulated submicroscopic particles of maximum resistance to slip in precipitation-hardening systems or the equally postulated submicroscopic non-metallic oxide or silicate particles to which grain size control and resistance to aging of steels are ascribed. Here we cannot directly see, photograph, nor measure whatever it be that is actually causing the phenomena, but must appraise them solely on the basis of the phenomena. We need a new finger print method for such cases.

There have been plenty of attempts to find such a method, with the ultra violet microscope, modifications of X-ray technique, analytical methods aimed to give some glimmer of light on the amount and composition of the sub-microscopic particles, and so on, without much avail. We have to adopt the rather crude method of trying to reproduce all the conditions obtaining in the preparation of those alloys that give the properties we want, without knowing just what it is we are trying to control.

In some fields where ordinary common sense does not clearly indicate what variables are involved so that a low-cost experiment to vary each single variable and hold all the others rigidly constant in the laboratory cannot be devised, and where the scale of commercial production is so large that one dare not intentionally change the variables in the wrong direction in order to get an accentuation of the defect or trouble, it is becoming more and more common to resort to probability methods and let huge numbers of observations show whether the results are or are not due to chance.

Technique for this is becoming improved and discussed, and will in time be understood by a larger number than it is now. Incidentally, Howe approached the problem of the effect of carbon in cast iron from much that point of view.

While we are waiting for the physicist to develop new tools to bring us unequivocal evidence on the things we now have to guess at, we should try to make our guesses more intelligent by utilizing more of the detective attitude and less adherence to dogmas that may appear in the textbooks but won't fit in the facts we already know.

At any rate, detective stories in plenty ought to be read by the metallurgist, for they should tend to give him an indispensable attitude of mind.—H. W. GILLETT

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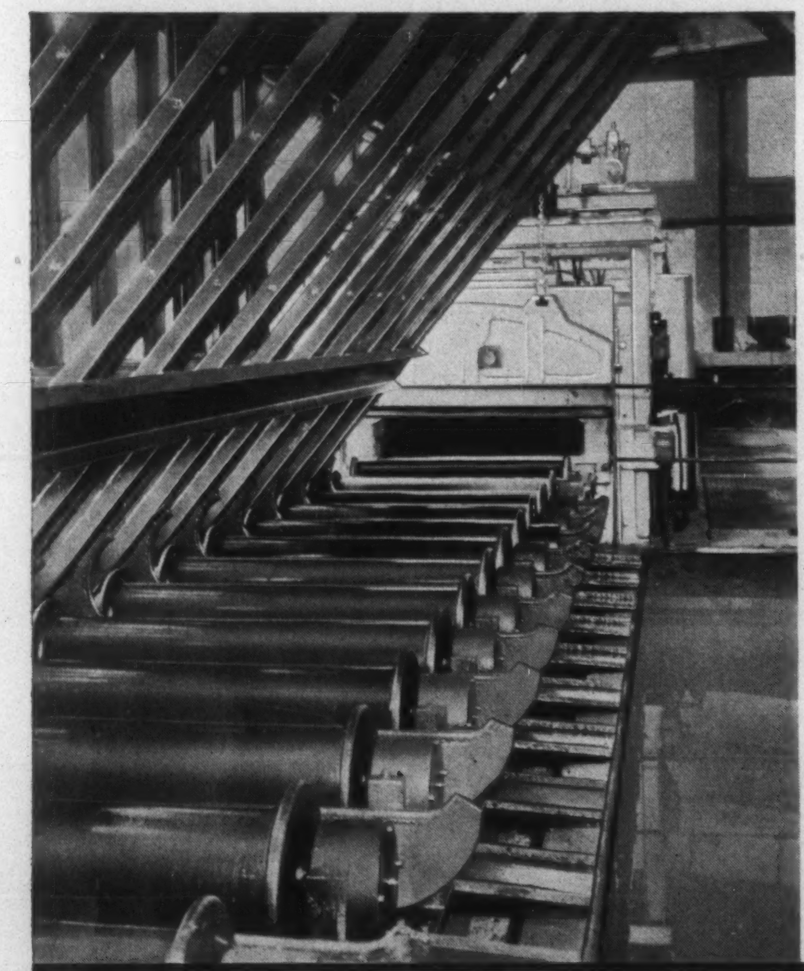

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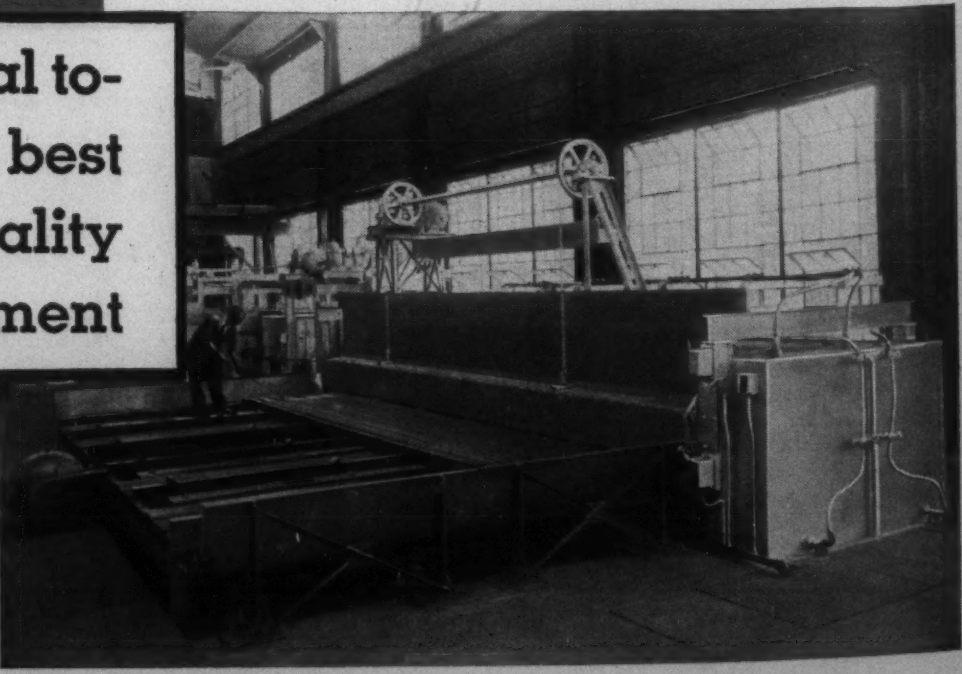

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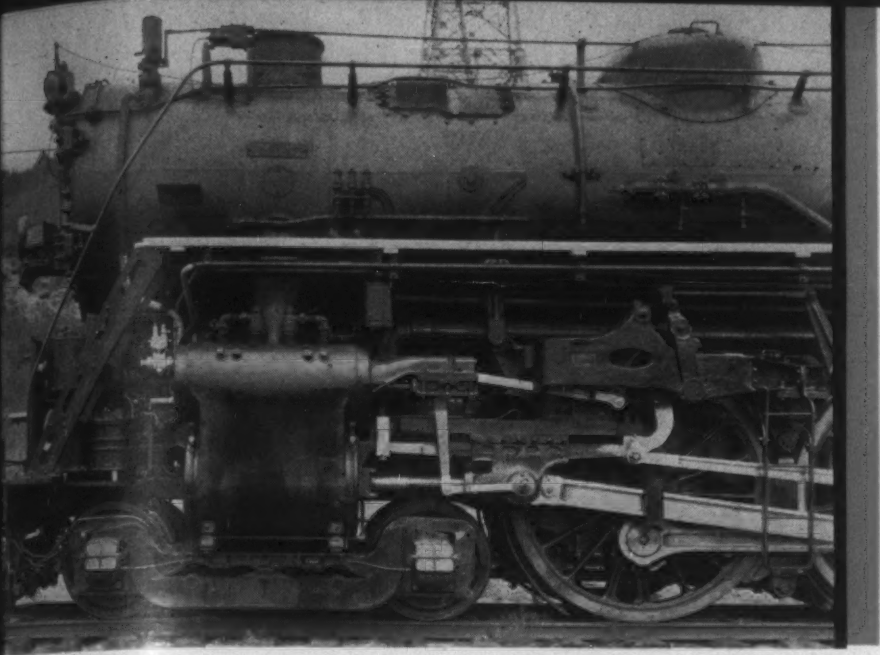

Hudson Type Locomotive

LOCOMOTIVE TIRES

A Discussion of the Causes of Typical Tire Failures

By Leland E. Grant *

FAILURES OF LOCOMOTIVE TIRES are not uncommon; serious wrecks due to such failures fortunately are uncommon. There are instances, however, where many lives were lost due to a tire breaking and derailing the train. Tire failures, therefore, must always be considered as potential sources of disaster. With this thought in mind is it not pertinent to inquire whether present practices in connection with tires are adequate to meet the service conditions involved? The trend has been toward heavier wheel loads as well as higher speeds for prolonged periods. To meet these conditions roadbeds have been improved and heavier rails laid. Recently both heat treated steel wheels and heat treated rails have received much attention as possible means for adequately meeting the more severe service conditions. Yet tires remain the same as they were two decades ago! The composition and physical properties have not been altered; neither have shrinkage tolerances nor condemning limits for road service changed since the standards were established some twenty years ago. But tires are made from essentially the same grade of steel as wheels and rails, both of which have had to be modified to meet the new conditions. Furthermore, though tires are subjected to more severe service than any other locomotive forging, they are the only important ones that go into service in the "as forged" condition. To make matters still worse they have a stress equal to approximately half the yield point imposed on them by the shrinking operation before they are put into service at all. In view of these facts is it surprising that tires fail? There are, in fact, indications that failures are becoming more common and are occurring in thicker tires than in the past. Is it not possible that tires have not kept pace with the tremendous improvements of modern locomotives? It seems evident that if the railroads are to keep abreast of the march of progress, and at the same time maintain the excellent safety records they have established, cognizance must be taken of the problem of securing adequate tires. In view of recent developments it is evident that the demands of the future will be for still higher speeds, and the failure of a tire on a locomotive traveling at 100 miles an hour is likely to be far more disastrous than the same failure at the present conventional speeds.

The author has had an opportunity to examine quite a number of failed tires during the past six years. Believing such failures to be a menace to the railroad, special attention has been given to each, and a thorough inspection made to determine the cause. The routine tests have included chemical analysis, hardness survey, microscopic examination, sulphur printing, persulphate and deep etching, as well as test bars for physicals. In many cases test bars were taken from various locations to determine what difference, if any, existed between the metal at the tread and the bore. Transverse test bars have been taken in the same manner and, in addition, test bars have been forged out longitudinally and transversely from sections of failed tires in an effort to learn more about the general properties of tire steel. Tires worn out in service have also been examined in hopes of discovering any general differences between them and the tires that have failed. It is the object of this paper to present a summary of this work. The result has been to cast doubt on the methods of making tires for developing the best properties of the steel. The failures are believed to be due in part to the quality of the metal, but not so much because of inherently poor quality as failure to develop the best properties during manufacture. The methods of handling tires on the railroads also are not above criticism so that both the manufacturer and the consumer must make changes before markedly improved tire performance can be expected.

Classification of Failures

There are, in general, four types of tire failures. First, there is the snap break, which usually occurs in a thin tire worn to near the condemning limit. There is no indication of progressive fracture or defect of any kind. The second is the progressive fractures, which may start in the bore or begin as flange cracks. Shelling is the third classification. This is the only type of failure that can ordinarily be detected early enough to prevent a service failure. It consists of a surface disintegration, usually in the center of

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* Chief Chemist, Chicago, Milwaukee, St. Paul & Pacific Railroad Company.

The "Columbian" Headed West from Milwaukee

the tread. It may be restricted to one small area but is likely to be more extensive. The last class comprises definite defects in the steel, such as pipes and internal cracks. These are not different from similar defects in other forgings.

Snap Breaks

Snap breaks are perhaps on the whole the most disturbing type of failures. Since there is no indication of progressive fracture, the indications are that the metal in such cases is unusually brittle, the stresses unduly severe, or possibly both. If it is brittleness that is responsible for these failures, it is clear that the usual inspection tests never reveal it. Because of their high carbon content tires are inherently brittle. Impact and drop tests are about the only method of evaluating brittleness, and, so far as the author knows, only the drop test is included in any tire specifications. It would appear as though the notched bar impact test should be of value in testing tires. Recent developments have indicated the impact test to have considerable usefulness in revealing unusual brittleness in different kinds of forging steel. By far the majority of failures in tires are of the same general nature as the impact test, a progressive fracture serving as the notch, and a sudden impact of the locomotive on the rail duplicating the blow from the falling tup. Unfortunately, the differences that may be expected in the impact value from heat to heat are small and may be within the limits of error of the method. If any tests have been made to determine the value of impact tests in selecting steel for tires, no account of them has been found in literature. Drop testing is a relatively expensive method of testing, requiring as it does the testing of a tire to destruction. For this reason it is not used as extensively as it might be. It has the advantage of telling something about the quality of the steel in the tire which is not the case with the type of heat test bar commonly used. It will be shown later that the type of test bar now employed has but little value and there would be no advantage in making impact tests on it. The recently developed torsional impact test devised by Luerssen and Green appears to be even better adapted for evaluating the toughness of steel such as is used in tires, than the Izod or Charpy test.

Stresses induced by too great a shrinkage may be the cause of some snap failures. The customary shrinkage allowance should result in a stress of approximately 30,000 lbs./in.^2 of cross section. But so far as the author knows this has never been checked by extensometer measurements and there are many factors that can influence the final load such as variations in roundness of both tire and wheel, taper in the bore, roughness of the surfaces, and accuracy of the dimensions. These large diameters are not subject to accurate measurement without special equipment and 1/64 inch makes a lot of difference in the stress. Another possible cause of high shrinkage stress is shimming. Tires sometimes become loose in service due to various causes and have to be shimmed to keep them tight. If the shim is too thick, or if it overlaps, excessive stress may be set up when the tire cools down again. Other factors that may be causes of snap tire failures are improperly counterbalanced wheels, rough tracks, flat spots, wheels out of round, or any other condition that sets up a severe hammering on the tire. A thorough check up of the mechanical practices involved in fitting and applying tires probably would eliminate most of the failures of this type.

The thickness at which a tire is condemned for road service also has a bearing on the prevention of this type of failure. The Federal requirements for condemning tires are based on axle loads as shown in Table 1.

Table 1

Weight per Axle	Diameter of Wheel Center, Inches	Minimum Thickness for Road Service, Inches
30,000 lbs. and under..........	44 and under	1¼
	over 56 to 62	$1\frac{7}{16}$
	over 74	1⅝
Over 30,000 to 35,000 lbs.......	44 and under	$1\frac{5}{16}$
	over 56 to 62	1½
	over 74	$1\frac{11}{16}$
Over 35,000 to 40,000 lbs.......	44 and under	1⅜
	over 56 to 62	$1\frac{9}{16}$
	over 74	1¾
Over 40,000 to 45,000 lbs.......	44 and under	$1\frac{7}{16}$
	over 56 to 62	1⅝
	over 74	$1\frac{13}{16}$
Over 45,000 to 50,000 lbs.......	44 and under	1½
	over 56 to 62	$1\frac{11}{16}$
	over 74	1⅞
Over 50,000 to 55,000 lbs.......	44 and under	$1\frac{9}{16}$
	over 56 to 62	1¾
	over 74	$1\frac{15}{16}$
Over 55,000 lbs................	44 and under	1⅝
	over 56 to 62	$1\frac{13}{16}$
	over 74	2

It will in general be found that snap breaks, like many other failures, occur in relatively thin tires worn to near the condemning limit. As the service becomes more severe these limits may need to be changed even though the axle loads are not greatly increased. On the Milwaukee Road failures of this kind have occurred on large power of the 4-6-4 type with the tires still 3 inches or more thick. This has led to changing the condemning limit for road service from 2 to 2½ inches on this class of power with 2¾ inches the limit for the last turning. Raising these limits has made it advisable to increase the thickness of the section of a new tire from 3½ to 4 inches in order to maintain practically the same amount of service metal.

Progressive Fracture Failures

As pointed out above, progressive fracture failures may start in either the bore or the tread, the latter being less common in our experience. Those beginning in the bore usually start near or at one side; occasionally one starts near the center. When the origin is on the tread side it invariably is in the flange section and the source is the heat checks which are always present. The outside edge of the tread will usually show heat checks though no failures have been en-

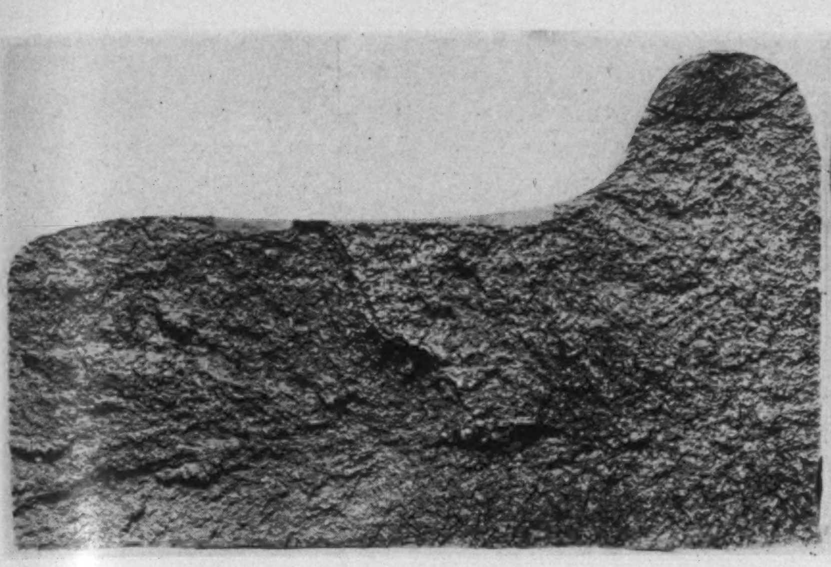


Fig. 1. Progressive Tire Fracture Originating in the Flange

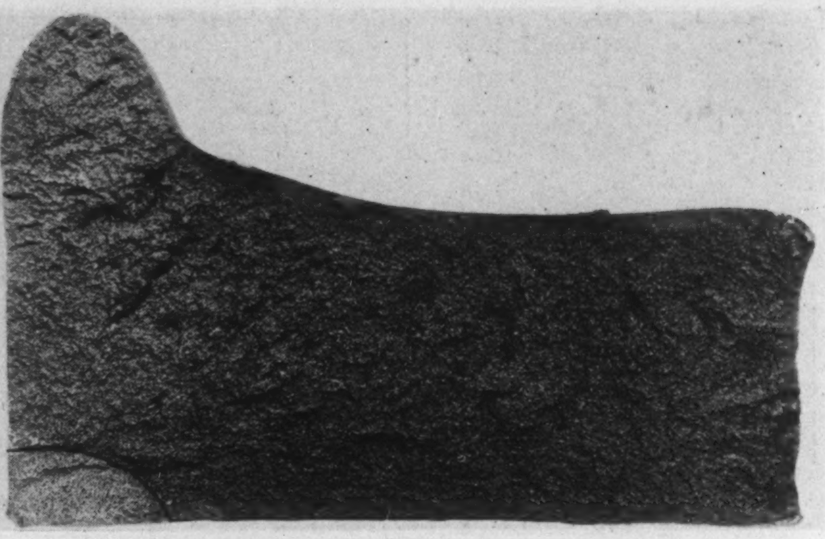


Fig. 2. Progressive Tire Fracture Originating in the Bore on the Flange Side

countered in which the fracture had started in this section. The center of the tread may or may not show heat checks; in many cases the surface wears away faster than cracks progress into the metal. Only one failure beginning in the center of the tread has been seen in this laboratory. The flange is subject to more severe braking effect than is the tread, being more completely surrounded by the brake shoe and wears down less rapidly, since only the side of it is in contact with the rail. Consequently the brake makes contact with the flange first. The rapid frictional heating produces checks giving the metal, under a low power magnifying glass, the appearance of being burned. These checks become the origin of fractures.

Flange fractures seldom show much of the typical smooth surface of progressive fractures. Fig. 1 shows a failure of this type. In this particular case the progressive area was not quite as smooth as it sometimes is. That part of the fracture above the line in the photograph was progressive. Complete failure frequently occurs with only ½ inch or less of the smooth surface. It does not appear probable that the tire snaps after the crack has progressed only this far. It must be borne in mind that the metal is under a heavy tensile stress, and once the crack has opened up a little, the stress may be so great that the parts are prevented from rubbing together and developing the usual appearance of a progressive fracture. Some examples have been seen which showed distinct evidence of having been cracked to a depth of 2 inches from the point of the flange when final failure occurred: yet they showed only a very small area of the normal, smooth surface of a progressive fracture. It can be expected that the spread of a fracture will be more rapid in tires than in many other locomotive forgings because of the high internal stress. The progressive fracture area of a failed tire will scarcely average 5% of the cross-section as compared with an average of more than 50% in most other locomotive forging failures.

Progressive fractures beginning in the bore generally start at or near one edge, or occasionally near the center. Our experience has been that the majority of bore failures start on the flange side of the tire, from ¼ to ½ inch in from the edge. Fig. 2 shows such a fracture. Here the origin was about ¼ inch inside. All the metal below the line in this case constituted the progressive area. Dendrites are especially prominent in this part of the fracture. The origin of the fracture may coincide with the edge of the wheel center when the center is only 5 inches wide. It is not evident why this area becomes the locus of origin of so many failures unless the sharp edge of the wheel acts as a stress raiser. When heat treated tires are used it is customary to round off the edges of the wheel center as well as the tire, experience having shown this to be helpful in preventing failures. This confirms the idea that the edge of the wheel center may act to produce high local stresses. Service conditions may also contribute as the flange is undoubtedly frequently subjected to severe impacts when the engine passes over a low frog. The stress may initially be higher on the flange side owing to the thicker section not yielding as readily to any irregularities as the tread portion. Deep etching often shows small tears in the metal adjacent to the origin of the fracture and it is probably in such cracks that the failures actually begin. Whether these cracks develop from tool marks or are the result of the tensile stress is

Hudson Type Locomotive

Fig. 3. Checks in the Bore of a Failed Tire in one of which the Fracture originated. Approx. Full Size

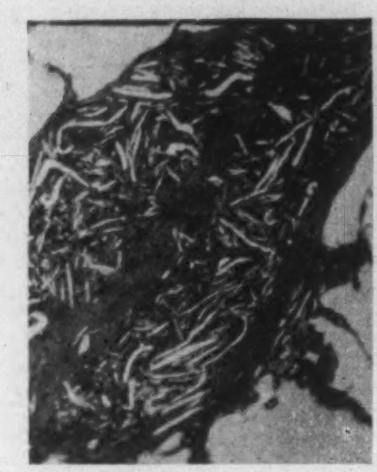


Fig. 4. Rust, Dirt and Steel Chips Forming an Apparent Slag Streak in a Shelled Tire. 500 ×

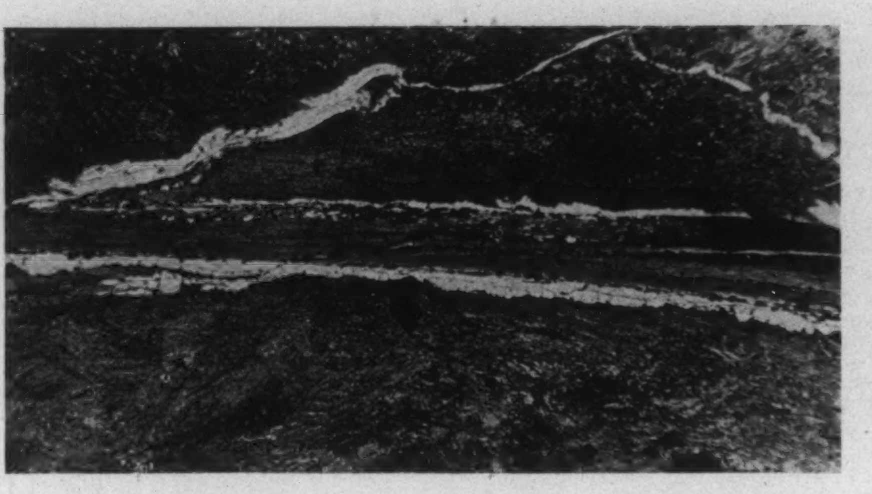


Fig. 5. Partially Welded Blowhole in a Shelled Tire. 100 ×

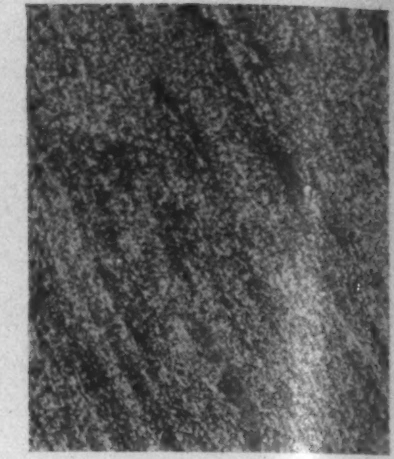


Fig. 6. Near the Surface of a Shelled Tire showing Cold Working Effect and Refined Grain Structure. 100 ×

not known. Frequently they have the appearance of having developed from the mark left as a chip breaks off in machining. Fig. 3 shows part of the bore section of a failed tire in which the fracture originated in just such marks, the entire surface being quite rough. It is possible that excessive stress caused these cracks to open up and the chip marks served merely as stress raisers.

Some bore fractures start in small, flat spots at the edge of the tire on either the flange or the outside edge. These flat spots may be caused by the edge being hit with a sledge in driving the tire on, or they may be the result of some blow in service. A crack starts in the flattened area and spreads, the smooth progressive area extending into the cross section only ½ to ¾ inch. When the fracture is in the center of the bore, as occasionally happens, a small defect is likely to be found similar to those described above, that is, a crack where a chip was broken off. Frequently, the tire is not flat in the bore but is concave. Whether this is done in machining or develops in service is not known. In any event it leaves the center of the tire unsupported, and when the tire wears down thin, extra stress is thrown on this portion and undoubtedly is instrumental in developing the failure.

Shelled Tires

Shelling is one of the most baffling of tire failures that is encountered. It manifests itself as a breaking down of the surface layers, usually in the center of the tread, but sometimes spreading to one side. It never affects the flange itself. The surface defect progresses in toward the bore at an angle about 45° to a radius. In machining a tire with a shelled tread, a cut ½ inch or more in depth may not be enough to remove all of the defective metal. This type of failure does not often result in complete fracture as the tire is removed before the disintegration proceeds that far. It is believed by some that shelling is due entirely to the service conditions causing a breaking down of the surface layers of metal. Others believe that some defect must exist in the metal, though just what this defect is has never been shown conclusively. Shelling is sporadic in character and it is difficult to see why only one tire on an engine will show shelling while the others do not. Similarly, two engines of the same type operating over the same track and hauling the same kind of loads do not both necessarily develop shelled tires. On the whole shelling is a much more common type of tire failure than any of the other types discussed above. This would tend to indicate that faulty material is not responsible for all shelling failures. Furthermore there seems to be good evidence that service conditions can cause shelling, particularly in cold weather. Heat treated tires have been reported to be an effective remedy in these cases. The success of heat treated tires in such cases does not, however, prove conclusively that none of the shelling was due to defective metal. It is possible that a defect, a small blow hole for example, which might cause shelling in an untreated tire, would not produce the same effect in the much stronger heat treated steel. The metal would simply wear down and the flaw never be noticed.

Microscopic examination of the metal in shelled areas will often show abnormal metal conditions There is, of course, the cold worked layer of metal where the surface layers have been battered. But at times there will be found a layer of ferrite just below this cold worked band or in between two layers of cold worked metal. The ferrite may border a crack that is welded in one or two places. Frequently the cracks are filled with rust and chips of steel which give the composite the appearance of a large slag inclusion. These may even be found well under the surface, so deep in the metal that it is difficult to believe they are not inclusions. Careful examination and etching tests, however, will reveal their true nature. Fig. 4 shows a section of one of these dirt streaks. The micrograph shows a complex structure, such as slag often has, but in reality this was nothing but a crack filled with dirt and rust. The light areas were flakes of steel, eroded from the edges of the crack as it spread into the metal; the darker parts were rust. When welded spots with bands of ferrite are found, there can be hardly any doubt that the tire originally had a partially welded blow hole, and that this was the fundamental cause of the shelling. Fig. 5 shows such a condition. There is every indication that the metal had a blow hole which was partly welded up during rolling. There does not appear to be any other reasonable explanation

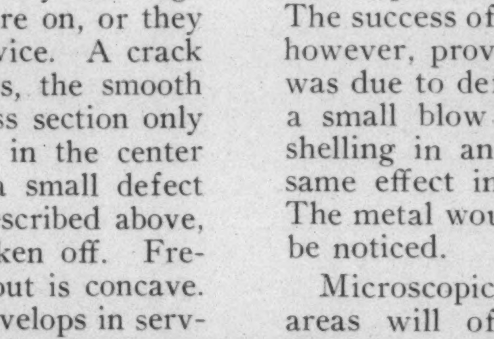


Fig. 7. Coarse Grain Structure of Tires as Rolled. 100 ×

of this condition Such areas are not always found, but patience in the matter of making sufficient specimens from a single shelled spot will often yield surprising results. Unfortunately in some cases the evidence has been destroyed; shelling has progressed so far that the defect has chipped out. Examination soon after shelling began might have told a different story.

Frequently in the examination of shelled areas black scales will be found. These appear to be shards of steel covered with black oxide. At first this would seem to indicate that there must have been at some time an opening from the surface of the steel into the interior and later the surface became scaled during heating for rolling. But decarburization will not always be found adjacent to such flakes of scale. Scaling during manufacture is, therefore, automatically eliminated as an explanation since this high carbon steel would be decarburized to a noticeable extent while such scale was being formed. The only other explanation appears to be heating during service. That the layers involved in a shelled area do at times get excessively hot is indicated by the refinement of the grain. The thin flakes, more or less insulated from the bulk of the metal by iron rust and dirt, heat very quickly owing to the lack of conduction to the cooler sections below. The steel becomes heated to above the critical point temperature as shown by the change in structure. When such temperatures are reached oxidation of the surfaces also occurs and the black scale is formed. Fig. 6 shows a section of metal close to the surface in a shelled area. It is evident that the metal has been heated very hot. The grain has undergone a change as compared with the base metal which was much like that of Fig. 7. The structure is now a coarse sorbite with the effect of cold working superimposed. If shelling was due to a gas pocket or other defect this condition might have developed after the metal had started to break down. On the other hand, if shelling was caused by service conditions such as wheels slipping it is possible that the sudden localized heating produced the grain refinement. The striations due to cold working developed later.

Having found the above conditions in the examinations of shelled tires in this laboratory, the author believes that defective steel, as one cause of shelling, cannot be entirely eliminated from the picture. It does not appear to be the sole cause. More work must be done on this type of failure before a complete explanation of the cause or causes can be given.

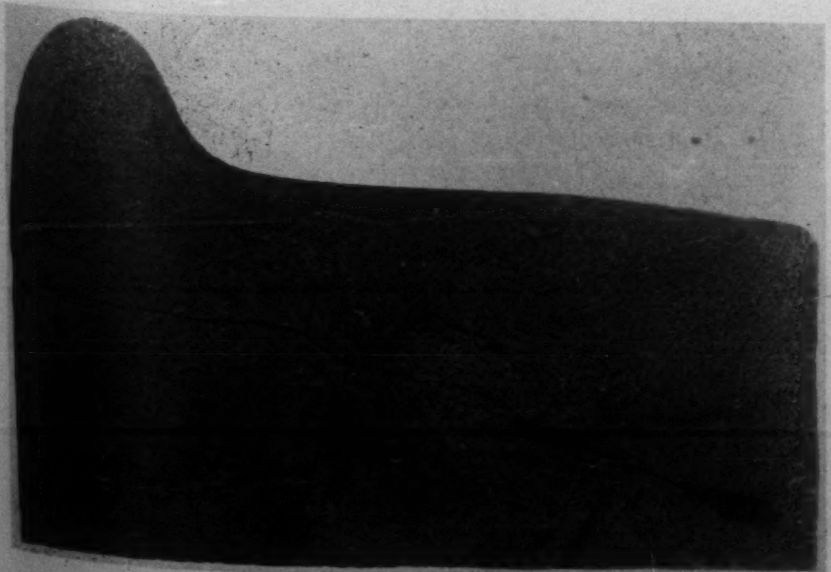
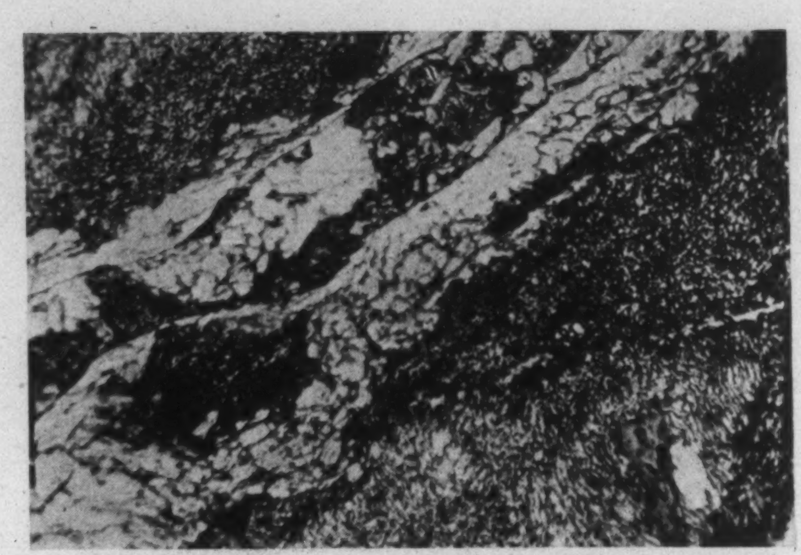


Fig. 8. Defective Tire



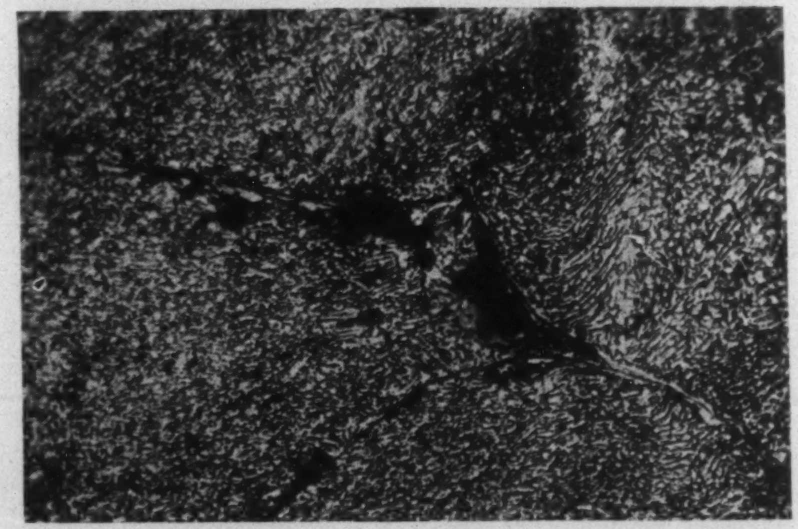


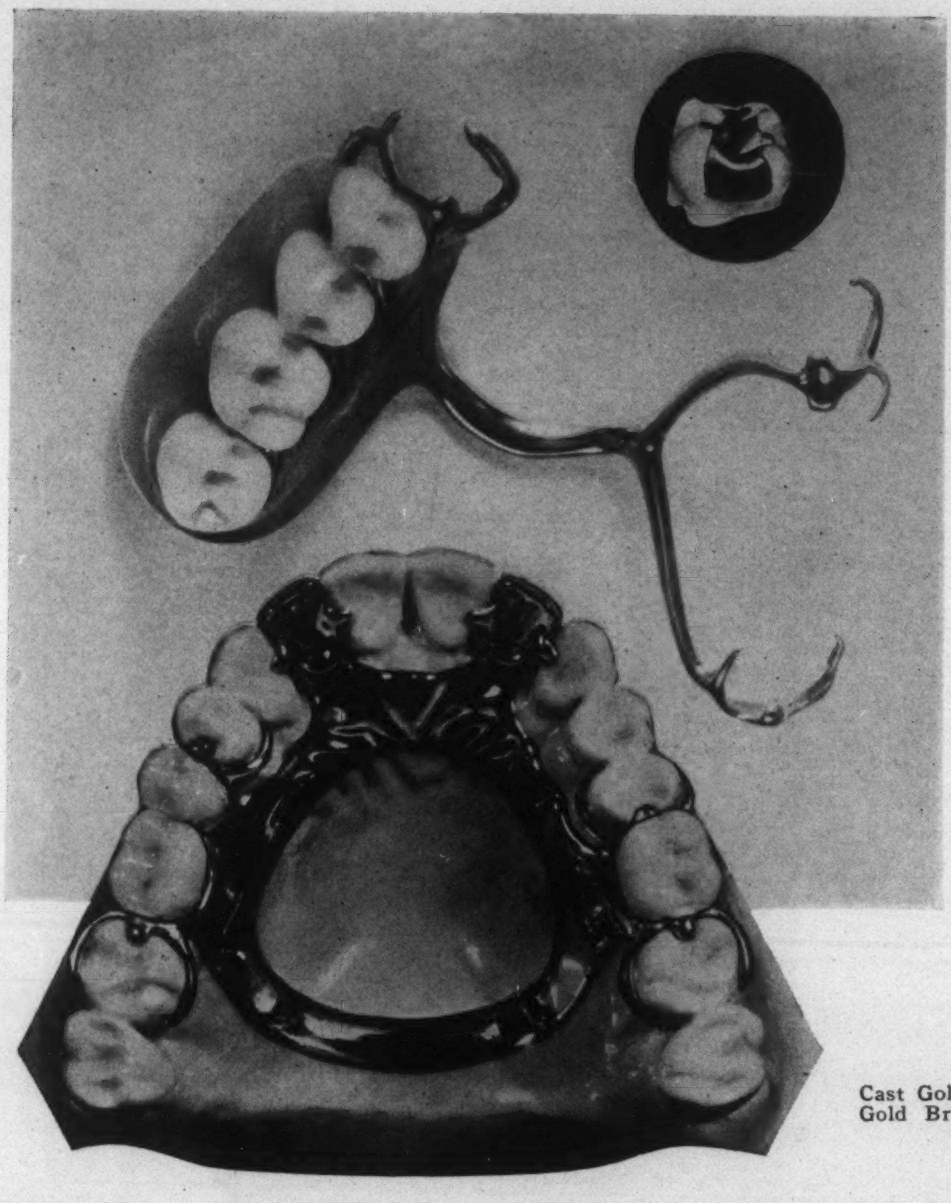
Fig. 9 (above). Remnant of a Blowhole in a Tire which Developed an Internal Rupture

Fig. 10 (below). Same Specimen as in Fig. 9. 1000 ×

Defective Steel

Under the heading of defective steel is included all obviously defective tires, such as those with large pipes, internal seams, and large gas pockets. These do not differ from similar defects in other forgings. Fig. 8 is representative of a common type of tire defect that has many manifestations. The cracks may not extend very far across the section, they may be vertical instead of horizontal, and in extreme cases there may be a wide crack throughout the greater part of the tire. These in general appear to be due to secondary pipes as considerable segregation is normally present in a fracture of this kind. Figs. 9 and 10 are from a type of failure that is not as common as the others. In this paper it is classed as a defect in the steel. The fracture begins in the interior of the tire and spreads to the surface generally shelving out to the surface at an angle. It presents somewhat the appearance of a transverse fissure in a rail except that it is not a square break. The condition is believed to be very similar if not exactly like that presented in Fig. 5. A blow hole existed in the metal and was partly closed in rolling. But a weakness existed and the working of the tire in service penetrated deep enough to cause the bad spot to act as the origin of a progressive fracture. These fractures normally show the typical rings of progressive fractures the same as those that have their origin at the surface. Defects, as a type of failure, form a moderately large percentage of the total failures; a much larger proportion than do similar defects in other locomotive forgings. This probably is not due to the production of more defective ingots in the tire industry but to the fact that the method of making tires is not well adapted to the detection of defective ingots.

(Continued in the December Issue)



METALS AND ALLOYS IN DENTISTRY

By Oscar E. Harder *

Cast Gold Partial Denture and Inlay, and Cast Gold Bridge. (Courtesy S. S. White Dental Manufacturing Co.)

IT IS DOUBTFUL whether the average client of the dental profession considers dentistry an important metal-using industry, even though his "dining equipment" may depend largely upon some of the most complicated alloys known to modern metallurgists. Yet statistics show that of all our industries dentistry is one of the chief consumers of our precious metals; for example, annual compilations frequently show more palladium used in dentistry than in any other industry.

The alloys used in dentistry have a wide range in their physical properties; for example, from pure gold with a tensile strength of about 15,000 lbs./in.², and the low-alloyed golds with a tensile strength of about 20,000 lbs./in.², to the more complicated alloys which in the wrought and heat-treated conditions have tensile strengths up to 200,000 lbs./in.² The more complicated alloys, such as those containing gold, copper, silver, platinum, palladium, and possibly nickel and zinc, are too complex for representations in equilibrium diagrams, and their phasial relations are only partly worked out at the present time. Many of these alloys respond to heat-treatment, and the improvement of their physical properties by this is as pronounced and as interesting as in the case of complicated alloy steels.

The beginning of the use of metals in the field which has now become known as dentistry undoubtedly has an ancient origin, although some of the records are incomplete and reports are sometimes conflicting. It has been reported that teeth of Egyptian mummies had been filled with gold. One author reports that gold was used in filling teeth as early as 1500 B.C. Files were used as early as the 7th Century A.D. in shaping teeth. The principle of the forceps for extracting teeth was included by Aristotle in his treatise on mechanics. The Romans were early users of lead for filling cavities. Gold leaf is known to have been used in the 15th Century and silver leaf as early as the 17th Century, but many preferred to use lead because of its greater softness. Fauchard, in his treatise on dentistry published in the 18th Century, discussed the use of lead, tin, and gold for fillings, but he expressed a preference for fine tin.

It appears that gold foil for filling teeth was introduced into the United States in 1795. Low-fusing metals were proposed and used about 1820. These alloys contained 50% bismuth, 31.25% lead, and 18.75% tin, to which mercury was sometimes added to lower the melting point.

Use of Pure Gold in Dentistry

Gold seems to have been one of the earliest metals to be used in filling tooth cavities, probably used first by the Egyptians, then by the Romans about the beginning of the Christian Era, and by the Arabians as early as the 8th Century. As stated, it was first used in the United States in 1795, when a man named Wolfendale brought a supply of gold foil from England. This was prepared by the well-known goldbeater's process, and the dentists managed to roll the foil into cylinders which were wedged and finally hammered into the tooth cavity. This foil was what is now known in the trade as non-cohesive gold. To the dental profession this means that the sheets are not welded together by hammering, and that it is, therefore, necessary to depend upon mechanical means of packing and holding the gold into the tooth cavity. It was not until about the middle of the 19th Century that a process for making adhesive gold was discovered. It was then

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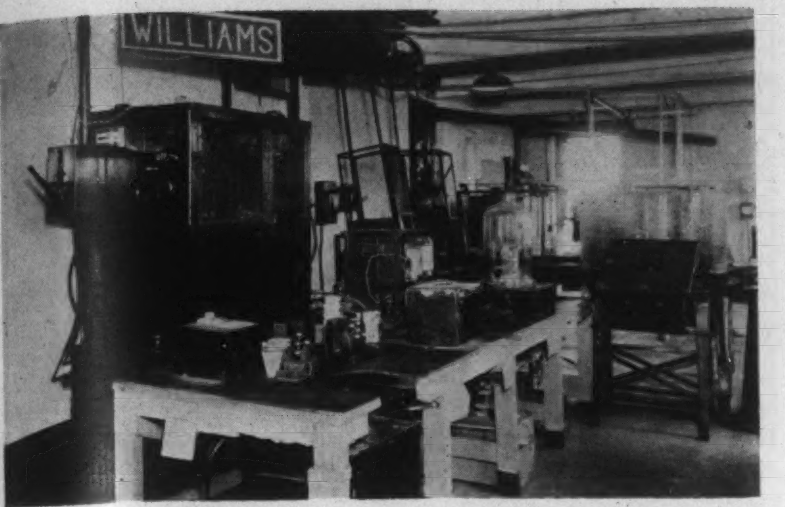
* Battelle Memorial Institute, Columbus, Ohio.



High-frequency Induction Furnaces for Melting Dental Gold Alloys. Attachments for Melting and Stirring Under Controlled Atmospheres and for Melting and Casting Under Vacuum Are Also Shown. (Courtesy the Williams Gold Refining Co.)

found that if the gold foil is pure, its surface clean, and it is annealed just prior to compressing into the tooth cavity, the foil can be made to weld into a solid piece. The modern gold foil inlay, then, in ideal practice represents a solid piece of gold formed by welding at the packing pressures, or as the dentist says, "condensing the foil," into the tooth cavity.

More modern methods of making the foil have replaced the old practice of gold-beating. Dentists may use a combination of non-cohesive and cohesive gold, in which some of the former is placed into the cavity at the beginning of the operation, but the cohesive gold is used in finishing the filling. Great care is required to keep the gold sufficiently free from impurities, particularly to avoid the presence of a film of moisture on the surface as it is being condensed, and to make sure that all of the thin sheets of foil are welded into one solid mass.

Use of gold foil has varied greatly in its popularity. At one time it was largely replaced by amalgam fillings which were much easier to make and less expensive. Later, the foil had a return to popularity only to find that it was again in severe competition early in the 20th Century with the development and extensive use of cast gold inlays. At the present time there is a lack of agreement in the dental profession as to how extensively foil restorations should be used. The relative softness of pure gold is against its use in restorations which are subjected to high stresses, although hardnesses as high as 77 Brinell have been reported. A highly skilled operator is necessary for production of a satisfactory inlay, and the hammering necessary to condense the foil properly into a solid piece of gold is not a pleasant experience to the patient. Foil inlays have a color that makes them somewhat more conspicuous than some of the lighter colored cast golds, and for that reason the esthetic effect may not be as satisfactory as when some of the lighter colored golds are used. The foil inlay is also in direct competition with ceramic materials such as cements and fused porcelains, which approach the natural tooth in appearance. The fact remains that dentists are still using foil inlays, and there are many who contend that for certain types of cavities the gold foil inlay is the best material available.

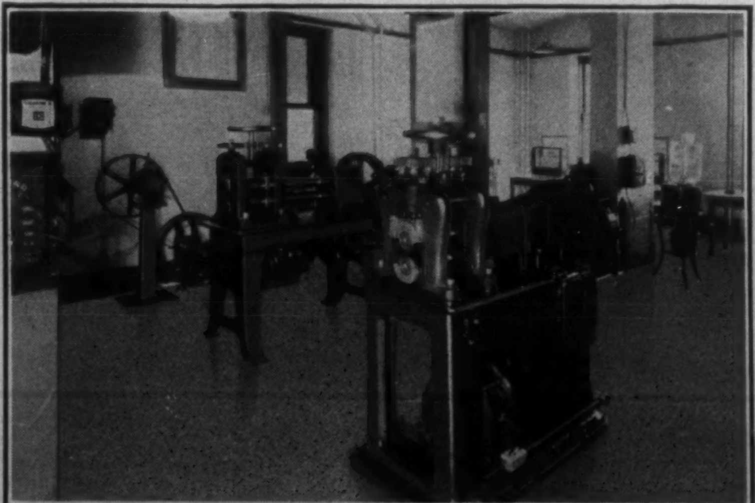
It is interesting to note that the present form of corrugated sheet that dentists generally use is said to have had its origin in the Chicago fire. The story is that books containing sheets of gold with papers between them had been in a safe during the fire, and it was found that the gold had been perfectly annealed and the shrinkage of the paper during the heating had given the foil this corrugated or crinkled appearance. It is now common practice to pack the sheets with alternate layers of paper, place them in a closed container, and heat them to a temperature that anneals the gold and gives it this corrugated form.

Amalgam Alloys

While mercury was introduced into some of the low-fusing alloys early in the 19th Century to give them a lower melting point, it was not until about the end of the first quarter of that century that the forerunner of the present amalgam alloy appeared. The first product was made from a finely divided silver mixed with mercury which would set into a solid mass. This became known as "silver paste." Shortly afterwards, silver coin containing copper was used in place of pure silver. Tin was also prepared in finely-divided form and mixed with mercury, but with rather unsatisfactory results.

In the early days of amalgam alloys it appears that there were unscrupulous promoters who abused both the amalgams and the patients, and about the middle of the 19th Century we find the dental profession in bitter controversy on the value of amalgams. From 1840 to 1855 was known as the "Amalgam War Period," in which many leaders in the profession resolved not to use amalgams in any form. Beginning about 1870, amalgam alloys were given scientific study. It was observed that silver with mercury tended to expand on setting, tin with mercury tended to contract, while copper with mercury showed neither expansion nor contraction. This scientific work soon improved the reputation of amalgam alloys, but it remained for Dr. G. V. Black of Chicago, after intensive research work, to announce in 1895-1896 what he termed a "balanced formula" for amalgam alloys, which has been the basis of the modern alloys for this purpose. He proposed an alloy containing 72.5% silver and 27.5% tin. When used in these proportions the tendencies of the alloys to expand or contract were supposed to be balanced. The present composition of amalgam alloy is indicated by the specification for amalgam alloys as recently proposed by the American Dental Association, which is as follows: Silver 65% minimum, tin 25% minimum, Copper 6% maximum, and zinc 2% maximum.

The manufacture of amalgam alloy is generally a closely guarded trade secret. It is known that the first alloys were prepared by melting together the desired metals, and then reduction to a fine state of sub-division by filing. Later, lathe turnings were used. Presumably, the general practice is to employ improved mechanical means of obtaining fine particles comparable to one of the older methods. Recently, a patent has appeared which provides for casting the alloy,



Break-down and Finishing Rolls for Dental Gold Alloys. (Courtesy M. F. Patterson Dental Supply Co.)

preparation of turnings that are ground to produce rounded particles, which are then classified into selected ranges of size.

In practice, the dentist takes the finely divided amalgam alloy, adds to this the proper amount of mercury, mixes these with a mortar and pestle (trituration), mulls the mass in the hands, and then packs the resultant product into the tooth cavity. During this operation there appears to be a solution of the amalgam alloy in the mercury, and this is followed by the formation of new compounds.

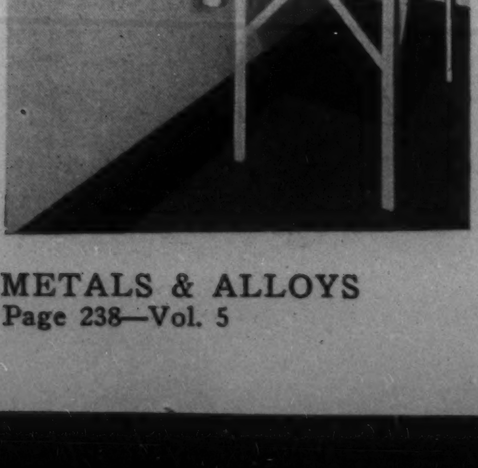
The amalgam alloy consists largely of the compound Ag_3Sn, and when that reacts with mercury it forms largely the two compounds Ag_3Hg_5 and $SnHg_3$. It is probable that the copper forms the compound Cu_3Hg_2. The strength of the amalgam alloy filling or silver filling, as they are usually called, depends upon the composition of the original amalgam alloy, the amount of mercury used in trituration, and the care used in packing it into the tooth cavity. It is not unusual for test specimens to show compressive strengths exceeding 40,000 lbs./in.^{2}; more than 60,000 lbs./in.^{2} has been reported.

When properly prepared, amalgam alloys constitute a valuable filling material for tooth cavities, but because of the dark appearance that develops in service, for esthetic reasons they are limited to the teeth which are not conspicuous. The possibility of mercury poisoning from amalgam fillings has attracted considerable attention, but the present opinion seems to be that there no longer is any hazard with properly made fillings in which the mercury is present mostly in the form of intermetallic compounds.

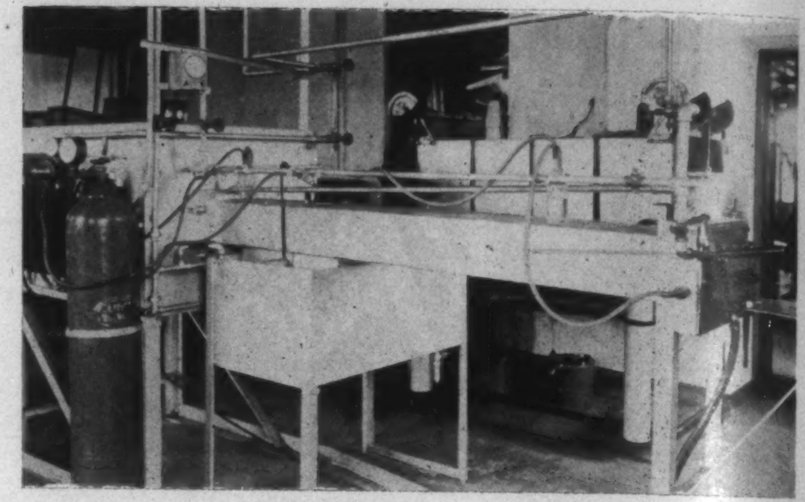
Gallium has recently been suggested to replace mercury in amalgams.

Manufacture of Gold Alloys

In general, the manufacturer of gold alloys uses virgin metals with a certain amount of back stock or scrap of the desired composition. Platinum and palladium are generally added in the form of thin strips after the other ingredients are melted, to effect ready solution of these high-melting metals. Melting is done in gas- or oil-fired furnaces, although considerable use has been made during recent years of high-frequency induction furnaces for melting special alloys, particularly those of high melting point. The alloys are cast into ingots which may be slabs or rounds, depending upon whether sheet or wire is to be produced. The dental industry seems to be unique in that alloys which are intended for re-melting are supplied in the form of sheets which have been rolled and carefully polished.



Pyrometrically Controlled Electric Annealing Furnace. (Courtesy M. F. Patterson Dental Supply Co.)



Hydrogen Annealing Furnace With Quenching Tank and Cooling Chamber. (Courtesy The Williams Gold Refining Co.)

Melting stock is generally supplied in one- and two-pennyweight sizes.

The ingots are broken down on rolls similar to those used in other industries, with the necessary periodic annealing, pickling, and other treatment. Finishing rolls are required to produce a very smooth surface, and sheet is generally polished before being cut into pieces for the trade.

Suitable ingots are cast for the manufacture of wire. They are hot-worked by rolling or swaging, and then finished by drawing through dies to suitable sizes. Here again it is necessary to employ intermittent annealing, and some of the alloys are quenched from the annealing temperatures to soften them. Some of the manufacturers are using hydrogen atmospheres in their annealing and heat-treating furnaces.

Casting Golds

The great impetus to the use of cast-gold inlays and other dental restorations came early in the present Century when it was shown that wax patterns could be formed in tooth cavities or shaped to a desired design, surrounded by a plastic material, such as a slurry of plaster of Paris and finely-divided silica which then set to form a mold, the wax removed by heating or burning, and the gold cast into the mold. Gold coin was early used for castings, but soon alloys of gold, copper, and silver, and then alloys of more complex composition containing in addition to these three metals platinum, palladium, nickel, and zinc.

During the period of about 1906-1912 the popularity of cast-gold inlays had increased so rapidly that it was predicted that the foil inlays would be completely replaced. This, however, did not prove to be the case. Not only are inlays prepared as gold castings, but much more complicated restorations are now being prepared as one-piece castings, as illustrated by the illustrations at the head of this article.

In the casting of gold-denture restorations some difficult foundry problems had to be solved, the problem of accurate dimensions being one of the most important. It became necessary to develop a casting procedure which entirely eliminated shrinkage due to the change of the gold from the liquid state to the solid state. This was overcome by casting under pressure, generally by centrifugal casting with proper gating and an adequate supply of metal to keep the molds full until solidification was completed. Shrinkage in the solid state still presented a problem, but the valuable work done by the National Bureau of Standards indicated the magnitude of this shrinkage and ways and means of compensating for it. Solid shrinkage of gold alloys is approximately 1.25% and research laboratories and practicing dentists have found that several methods are available for compensation. The wax pattern can be expanded somewhat by investing it at slightly elevated temperatures, and the mold, consisting of plaster of Paris and silica, or preferably cristobalite, can be heated to selected temperatures, so that the desired expansion is obtained, thus resulting in a casting which is made to extremely close tolerances.

Composition of Casting Golds

The composition of casting golds used in dentistry varies over a wide range, depending upon the intended service. Another variation depends upon the color of the gold desired, in one case the alloys being designated as gold color and in the other as platinum color. For inlay casting golds of gold color, the American Dental Association Tentative Specification 5 classifies them into three groups: 1. Very soft inlay golds; 2. medium inlay golds; and 3. hard inlay golds. These are designated as A, B, and C respectively in the following table, which shows the requirement for these golds as to composition, hardness, tensile properties, and fusion temperature:

Detail Requirements for Dental Inlay Casting Golds (Gold Color)

Type	Gold and platinum group metals, %	Silver, %		Brinell number		Elongation, 2-inch gage length, %	Yield point, lbs./in.^{2}	Fusion temperature, °F.
	Min.	Min.	Max.	Min.	Max.	Min.	Min.	Min.
A	83	3	12	40	75	18	.....	1725
B	78	0	15	70	100	12*	22,000	1650
C	78	0	15	90	140	12*	27,000	1650

*This value shall be reduced 0.5% for each 1% of platinum group metals in the alloy, and 8% shall be the minimum elongation allowed for any alloy.

The general practice is to maintain a percentage of the gold and platinum group elements high enough to assure tarnish resistance of the golds to the oral fluids.

Heat Treatment of Gold Alloys

Many of the gold alloys used in dentistry respond to heat treatment. This was recognized by manufacturers many years ago, but it remained for the Russian investigators Kurnakow, Zemczuzny, and Zasedatelev,[1] from their studies of gold-copper alloys, to suggest the mechanism involved in heat-treating such alloys, and its application to dental alloys was pointed out by the writer[2] in 1923.

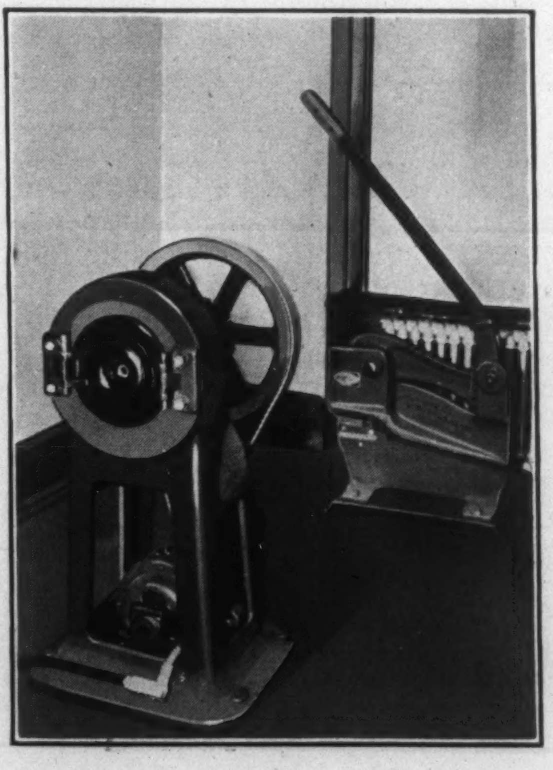
It has been found that on slow cooling, gold-copper alloys form two intermetallic compounds, CuAu and Cu_3Au, corresponding approximately to 75% gold and 25% copper, and 50% gold and 50% copper, respectively. The compound CuAu is the only one that is of particular interest in dental alloys. This does not exist in the alloy as it solidifies or in alloys that are rapidly quenched from temperatures above about 500° to 600° C. It does, however, form in alloys that are slowly cooled throughout the range below 425° C. and in quenched alloys that are reheated in this range of temperature. The formation of the compound greatly increases the hardness and strength of the alloys with corresponding loss in ductility.

It has become a common practice in the heat treatment of dental golds for testing purposes, and to a lesser extent in practice, to quench from 700° C. (1290° F.) to soften the alloys and then reheat to 400° C. (752° F.) and slowly cool to harden and strengthen them. The quenched alloys are much lower in strength and have greater ductility, in which condition they are more easily adjusted as to shape, while for service requirements the higher strengths are developed by reheating. It has now been found that copper-platinum and copper-palladium alloys show a similar phenomenon, and it appears that the formation of compounds of copper with gold, platinum, or palladium is the basis of heat-treating dental golds.

Because of the complicated nature of the alloys containing other metals that modify these reactions, and the possible presence of all three of these elements which form compounds with copper, exact details of the mechanism are not completely understood. However, it is now becoming common practice to heat treat dental alloys to develop the properties desired.

Wrought Golds

It is in the wrought-gold alloys that one finds unusually high physical properties. The metals contained in such alloys are similar to those found in the casting golds, but because of the higher content of the platinum-group, metals the gold content is considerably lower, values down to 55% being found. On the other hand, the platinum content is generally higher, this alone being as high as 20%, and the platinum and palladium content may run as high as 25%. In most cases, these alloys respond to heat-treatment, as discussed in the case of the casting golds, and the tensile strengths of the hardened alloys are frequently 50% higher than that of the quenched or softened alloys. Tensile strengths close to 200,000 lbs./in.^{2} and Vickers hardnesses up to 350 are found in these heat-treated wrought-gold alloys.



Wire Swaging Machine for Gold Alloys. (Courtesy M. F. Patterson Dental Supply Co.)

An indication of what is required of these alloys is given in the following table quoted from American Dental Association Tentative Specification 7, for dental wrought-gold-wire alloys:

Detail Requirements for Dental Wrought-Gold Alloys

Gold and platinum-group metals, %	Fusion temperature wire method, °F.	Ultimate tensile strength, lbs./in.^{2} "oven-cooled"*	Yield point, lbs./in.^{2} "oven-cooled"*	Elongation 2-inch gage length % quenched	"oven-cooled"
Min.	Min.	Min.	Min.	Min.	Min.
75	1,750	150,000	125,000	15	4

* "Oven-cooled." Placed in a furnace at 1290° F. (700° C.) for 10 minutes and immediately quenched in water at room temperature, then placed in the furnace at 840° F. (450° C.) and uniformly slow cooled to 480° F. (250° C.) in 30 minutes.

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[1] Journal Institute of Metals, Vol. 15, 1916, pages 305-331.

[2] Gold Casting. Journal American Dental Association, Vol. 10, 1923, pages 869-874.

Gold Solders

Gold solders are supplied to the trade with the indication that they are to be used with 22-carat, 20-carat, and 18-carat, and other golds. The fineness is generally given. The composition of the solder is adjusted so that it has a lower melting point than the gold alloy on which it is intended to be used. In other words, solder for 18-carat gold is intended to match 18-carat gold with reference to color, but to have a melting point low enough that the solder can be applied without melting the gold. The melting point or melting range of solders and the color are adjusted by selecting the composition, which usually includes gold, silver, copper, and zinc; some manufacturers also include tin. The zinc and tin serve to lower the melting point.

Gold solders also respond to heat treatment much as do the casting golds previously discussed.

Fluxes are generally used with gold solders. Fused borax and boric acid are the principal constituents of these fluxes, although additions of sodium carbonate, sodium silicate, sodium chloride, and sodium and calcium fluorides have been used.

Platinum

In addition to the use of platinum in dental gold alloys, in which the platinum content may run as high as 20% in some of the higher strength platinum-colored alloys, platinum has considerable use as a pure metal. In the form of sheets or foil it is used as the matrix for porcelain inlays, porcelain-jacketed crowns, and plates for dentures; and in the form of wire it is used for pins in attaching porcelain facings to gold castings. Attempts have been made to develop substitutes for platinum as pins, but the results have been only partly satisfactory. Some progress was made in the use of gold-palladium and silver-palladium alloys and of tungsten and molybdenum wires which were gold-plated to make it possible to solder onto the wires.

Platinum is also used as a heating element in furnaces intended for firing porcelain, and platinum thermocouples have to be used in measuring the temperature of these furnaces.

Palladium

During the World War, when the use of platinum was restricted and the price was very high, palladium came to be extensively used, in place of platinum in various dental alloys. The lower density of palladium (12.16) as compared with that of platinum (21.37) immediately means that for a given weight of metal the palladium has a much greater volume. The price of palladium per ounce is generally in its favor at the present time, this being about two-thirds that of platinum.

Palladium may be used to whiten the color, increase the strength, and raise the melting point of gold alloys. Early in the development of the use of palladium in dentistry, alloys containing as much as 50% of palladium with silver or with gold were used. These alloys are white in color and are less conspicuous in the mouth and, therefore, may be preferred for esthetic reasons.

The present greatly increased cost of gold has intensified the interest in the use of palladium, and it is now being extensively used to replace gold. The price per ounce is about three-fourths that of gold, and its weight per unit volume is only about two-thirds as great.

Illustrative of some of these new high-palladium casting alloys are the following:

Metal	%	Metal	%
Gold	10-20	Gold	10-15
Silver	40-50	Silver	27-50
Palladium	20-30	Palladium	22-30
Copper	10-18	Copper	10-20
Zinc	1-4	Indium	0.5-5

As palladium forms intermetallic compounds with copper, many of these alloys respond to heat treatment, and certain compositions develop very high tensile properties.

While metallic palladium is soluble in nitric acid, it is considered sufficiently corrosion-resistant to the oral fluids, and the use of nitric acid can be avoided as a pickling medium. By proper alloying, the solubility in nitric acid can be avoided.

The indications are that if the present price of gold is maintained there should be a marked increase in the use of palladium in dental alloys, and a more extensive use of white alloys in place of the gold-colored ones.

Nickel

Nickel is used in certain alloys, largely as a substitute for platinum and palladium in giving increased strength and hardness. In small amounts (0.5 to 2%) provided that the gold plus the platinum group metals is kept above about 75%, nickel has little effect upon the tarnish resistance. On the other hand, if higher percentages of nickel are used, and at the same time the amount of gold plus the platinum-group metals is decreased, the tarnish resistance of the alloys is seriously impaired.

Stainless Steels

It was early recognized that stainless steels containing 12 to 14% of chromium and about 0.3% of carbon were well adapted to the production of certain dental instruments. When properly heat treated, they had good corrosion resistance and could be made to have a relatively good cutting edge. With the discovery and development of the more corrosion-resistant steels of the 18-8 type (18% Cr and 8% Ni), their application in dental restorations has also been developed. Development was done largely in Germany, but their use is now making considerable progress in the United States. These stainless steels are cheaper, have higher strength than some of the gold alloys, and have good corrosion resistance when properly heat treated. They have found use in base plates for full and part dentures, clasps, crowns, and orthodontial wire. While these parts are usually made by die pressing sheets, certain modified compositions can also be cast. Stainless steel denture appliances are generally assembled by spot welding, but it has been found that they can be soldered with gold solders, particularly if the stainless steel is gold plated before soldering.

Other Alloys

Space does not permit detailed discussion of many other alloys used in dentistry, but brief mention may be made of some of them:

Silver solders containing silver, copper, and zinc, or silver, copper, zinc, and tin.

Fusible alloys containing two or more of the metals bismuth, cadmium, lead, and tin.

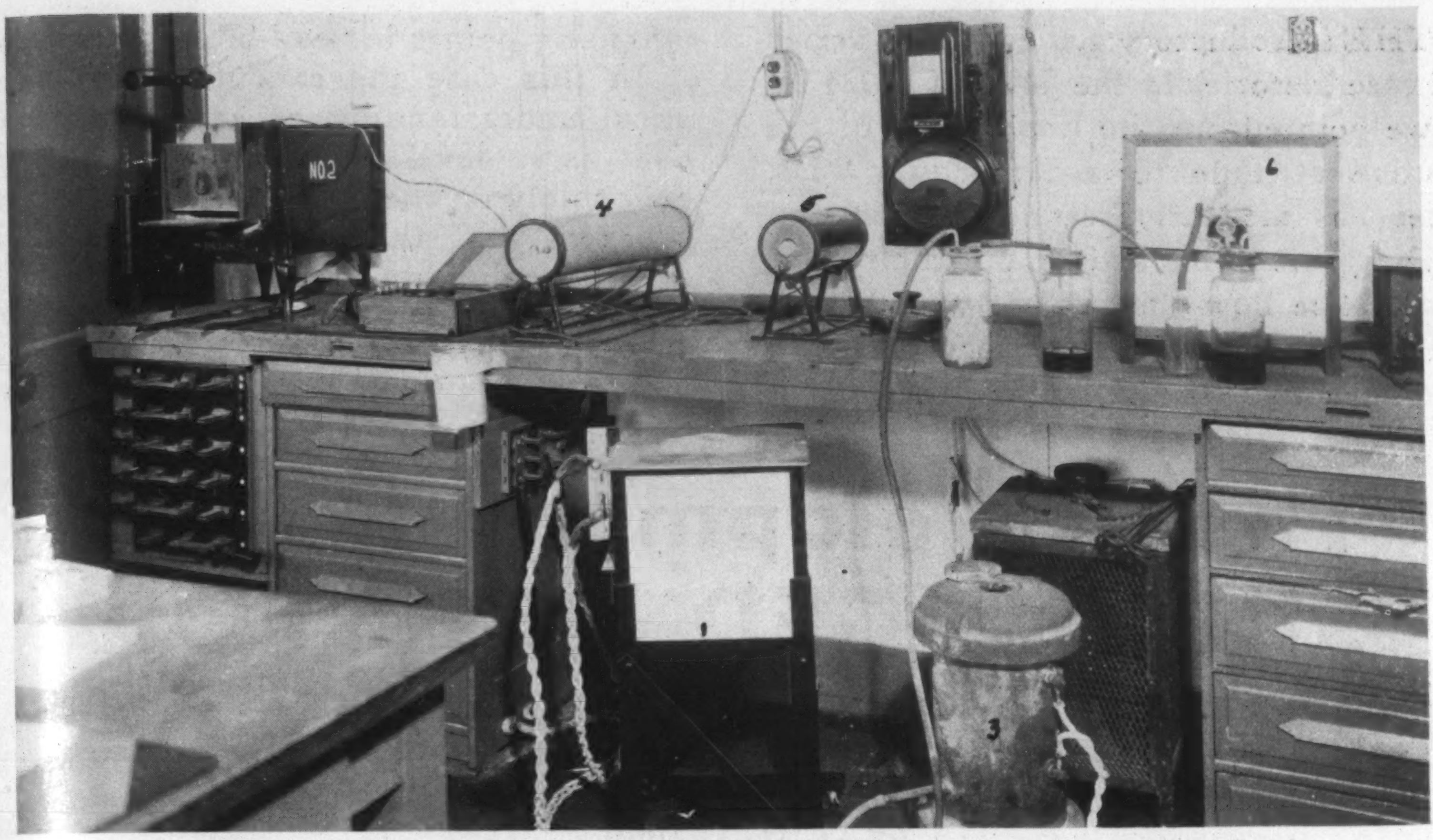
Alloys for dies and counter dies, generally low-fusing alloys.

Nickel-silver containing nickel, copper, and zinc.

Heat-resisting alloys of nickel and chromium, or nickel, chromium, and iron.

Technic alloys, composed principally of copper and silver with additions of gold, nickel, or tin.

Dental instruments represent a great variety of plain-



Laboratory View Showing Equipment for Thermal Analysis, Fusion Tests, and Heat Treatment of Dental Golds. (Courtesy The Williams Gold Refining Co.)

carbon and alloy steels, including the stainless steels. The number of instruments required in the modern dentist's office may be indicated by the report that one dentist has developed 42 instruments specially designed for use in making gold foil inlays.

Among the other alloys used in dental instruments will be found a special type of Stellite, used because of its corrosion resistance. Spatulas made of metallic tantalum are used for mixing dental cement because of their abrasion and corrosion resistance. Many dental instruments were formerly nickel-plated, but now they are frequently chromium plated. Monel and stainless steel find extensive use in trays, pans, and parts of dental machines.

Dental Research

The beginning of the use of metals in dental restorations is undoubtedly of ancient origin. Some valuable research work was done in the United States during the latter part of the 19th Century. Dental manufacturers have been engaged in metallurgical research at least during the present century.

A great impetus to this type of research was given by the valuable work started at the National Bureau of Standards about 16 years ago, and now being continued as a coöperative work by that Bureau and the American Dental Association. Although the practising dentists, the dental laboratories, and the dental manufacturers[*] were slow to recognize the importance of this work and to make application of the findings, during the past few years this research program has had a pronounced effect in this country. Practising dentists and dental laboratories have become interested and are making practical applications of the scientific findings. In general, the manufacturers of dental alloys have established their own research laboratories and are making new and important developments, both in the form of new materials and better methods of processing old materials.

Dental Laboratories

Formerly, each dentist handled the entire case of making the restoration. During the present century there has developed a marked tendency for specialization, not only by individual dentists but by laboratories which will give special, and in some cases general, dental service. While at the present time many dentists continue to handle all of their work, others send it out to special laboratories. It is, of course, still necessary for the operating dentist to prepare the case, and certain jobs he must still handle himself if he uses such materials as amalgam and foil fillings. However, the tendency during recent years has been to make more and more use of the laboratories, and some of these have developed into extensive organizations; for example, one laboratory in this field has had as many as 200 employees.

Conclusion

In conclusion, it is evident that the dental industry is an extensive user of metals and alloys, especially the precious metals, and the industry is both metallurgically and research-minded. The modern dentist is prepared to discuss with his client the corrosion resistance, fatigue resistance, modulus of elasticity, tensile strength, elastic limit, hardness, elongation, coefficient of thermal expansion, and casting shrinkage of a wide range of metals and alloys. He is prepared to place at the disposal of the client, materials ranging in hardness from about 30 to 350 Brinell hardness and with tensile strengths from about 15,000 to nearly 200,000 lbs./in.^{2}. Dental colleges require all students to take a special course in dental metallurgy, and many of our educational institutions are conducting research on the metals and alloys used in dentistry. The manufacturers of dental golds and other alloys compare favorably with any other industry with reference to their interest and activity in research and development work. They are manufacturing an extensive line of materials which must meet rigid requirements in a highly competitive field. New and interesting developments are continually being announced by these manufacturers.

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[*] Some of the larger manufacturers had done valuable work prior to that at the Bureau of Standards, but there was limited publication of findings.

IN THE introductory article to this series of case histories in the January, 1934 issue, we pointed out the importance of the executive attitude toward research. Dr. Clamer has modestly refrained from emphasizing this in his article, but the reader can visualize how the project would have fared in the hands of many executives who would have made the stumbling blocks into stopping points instead of stepping stones.

In this case the executive had a technical understanding of each fundamental fact as it developed instead of having to rely solely on the appraisal of the technical workers and that information combined with a realization of the value of the goal kept him on the path when an executive of lesser knowledge and narrower vision would have turned back.—H. W. Gillett

The Development of the SUBMERGED RESISTOR INDUCTION FURNACE

By G. H. Clamer*

No. 7 in a Series of Case Histories in Metallurgical Research

IT WAS IN 1911 that I first became interested in electric melting furnaces. I was at that time working on a research problem, the solution of which seemed possible only through the use of an electric furnace. That particular problem is, however, still unsolved, although I am today nearer to solution of it than I then was. Although I had the vision of an electric furnace for solving this problem, I had no conception whatever of the amount of time and money that might be necessary to perfect a furnace that would meet my requirements.

The electric furnace at that time was not yet completely "sold" to the steel industry. It was still passing through the stage of infant diseases and troubles. It had not been thought of as a practical equipment for brass melting. The only tests in melting brass that had been made up to that time were made by The American Brass Company and by the General Electric Company. Tests conducted by The American Brass Company were made in an open ring type induction furnace of the Kjellin type, which had been designed for steel melting. The experiments were discontinued after finding that the molten brass in the ring shaped crucible was thrown out of the crucible by almost explosive violence, due to the manifestation of "pinch effect." The experiments of the General Electric Company were made with a revolving, barrel shaped furnace with an over bath arc. This furnace was the forerunner of furnaces of that type now on the market. It was known as the Weeks Furnace, being named after its inventor, Charles A. Weeks, a Philadelphian. Dr. H. W. Gillett invented and patented the rocking feature later applied to the over bath arc type furnace. Such furnaces are now extensively and successfully used, mostly for melting the lower zinc containing alloys.

I was at that time frequently thrown into contact with Dr. Carl Hering, a prominent electrical engineer in Philadelphia. Dr. Hering had been working with electric furnaces, and was of the opinion that it would be possible to pass currents of exceedingly high density through molten metals. In his experiments he led power into molten metal through electrodes instead of inducing the current in a ring of molten metal as is done in the induction furnace. He passed electrical energy through molten metal held in an open trough of U form. To his surprise, the molten metallic conductor, after a certain current density was exceeded, constricted in cross section at a point furthest removed from the electrodes. Accompanying this phenomenon was a whistling sound and he thought a hole had broken through the refractory at the bottom of the trough and the metal was there escaping. He later found by further increasing power the molten conductor could be completely snapped off and the power input thereby shut off. As the molten conductor assumed the appearance of having been constricted in cross section, much the same as a rubber tube would have if clamped by a pinch cock, he humorously referred to the phenomenon as "pinch effect," by which name it has ever since been known and referred to in the technical literature.

Dr. Hering explained his observations to Dr. E. F. Northrup, who worked out the theory underlying the phenomenon and originated the formula for its quantitative determination. He stated the law as follows:

> In parallel conductors free to move and in which currents flow in the same direction, a force is exerted that tends to bring the conductors together. A liquid conductor may be considered a bundle of parallel conductors.

The formula of Dr. Northrup has been generally accepted and used for calculating the magnitude of this force.

With a knowledge of the theory of the pinch effect as developed by Dr. Northrup, Dr. Hering now conceived the idea of designing an electric furnace in the form of two enclosed columns of liquid metal in contact with electrodes at the outer end for supplying current and joined by the liquid metal of a bath submerging them at the other. He reasoned that if it were possible to maintain on these columns of liquid metal a sufficient hydraulic head the breaking of the electrical circuit due to the "pinch phenomenon" could be overcome. His reasoning was correct; namely, that liquid metal would be forced out from the center of the molten resistors in such a furnace and that the liquid metal above would flow in on the periphery of the resistors, thereby causing a continuous and automatic electro-dynamic circulation.

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* President, The Ajax Metal Company, Philadelphia, Pa.

Up to the time he came to me with the idea, Dr. Hering had not proved his assumptions beyond having made some experiments with mercury in glass containers and having made a few unsuccessful trials on a slightly larger scale. He was of the opinion that a practical test of his ideas could be made by the expenditure of $500.00. Briefly stated, we were able by the expenditure of approximately that sum to demonstrate with a small furnace in which tin was melted, the soundness of the following ideas:

1. That very heavy power could be forced into such a furnace.
2. That the breaking of the circuit due to "pinch effect" could be overcome by hydrostatic head.
3. That the metal would circulate violently.

Such a furnace really was an automatic, valveless pump for the circulation of molten metal. The initial experiments were sufficiently encouraging to lead us on.

The Hering furnace, as it may be described, consisted simply of electrodes, resistor channels holding molten metal, and a bath of metal above. Simple as it may sound, the development work with this type of furnace was given up only after the expenditure of over $100,000.00 jointly by ourselves, The Scovill Manufacturing Company and the National Cash Register Company; these companies having coöperated with us in attempting to construct a practical furnace using electrodes. Following were the difficulties encountered but not recognized at a sufficiently early stage to understand the grave nature of the same:

The electrodes, because of the necessity for carrying enormous currents, must necessarily be made of metal. Dr. Hering, a few years prior to the time we began our development work, had conducted an elaborate research resulting in his working out the correct proportioning of electrodes for varying power input, whereby the lowest heat losses through the electrodes resulted. The result of his research work may be summed up in the following statement: *If electrodes are so proportioned that the current in same will heat the inner ends to the furnace temperature, the total combined losses will be the least possible, and the electrode will at the same time abstract no heat from the charge; it will then in effect act as a perfect heat insulator, better even than the walls, as far as chilling the product is concerned.*

Unfortunately, Dr. Hering's experiments were conducted by using direct current. He calculated very carefully the proportioning of the electrodes in the furnaces we subsequently built. It is readily understandable when using metallic electrodes with their high heat conductivity, as well as high electrical conductivity, that enormous heat losses might easily result. The electrodes were in direct contact with the molten bath, and the path of the heat flow was, therefore, unobstructed. In accordance with the theory of electrode proportioning so carefully worked out by Dr. Hering, he was fully convinced that by proper proportioning of the electrodes the flow of heat from the furnace outwardly through the electrodes could be blocked. He believed that heat losses resulting from the I^2R losses were the only losses to be reckoned with so far as the electrodes were concerned.

As I have above stated, Dr. Hering's electrode experiments were conducted with direct current. When alternating current was used, as was essential in order to meet practical conditions, his calculations were completely upset due to the manifestation of "skin effect." "Skin effect," although at that time known, was not nearly so well understood as it is today, and especially there was very little knowledge on the subject in connection with the tremendous currents required in his furnace. This first difficulty led to many experiments and much grief in attempting to find a means for overcoming electrode losses.

Naturally, as the electrodes heated the I^2R losses became greater. This alone was a very disturbing factor affecting the electrode proportioning formula, but the most disturbing factor was the "skin effect." As the heat from the furnace through the path of the resistors flowed back into the electrodes, the electrodes reached the molten state. This naturally suggested water cooling. Although it was not a very comfortable feeling, because of explosion hazard, to be experimenting with water cooled electrodes in a furnace that was known to exhibit a great outward flow of heat from the furnace through the electrodes, we nevertheless continued with water cooled electrodes until the development work on the Hering electrode type of furnace was abandoned. I well remember the remark made to me by our patent attorney when I submitted to him the Hering patent application. He numbered among his clients one of the large electrochemical concerns at Niagara Falls and, therefore, had experience with the handling of large power through water cooled electrodes. His remark was as follows: "This looks to me like a water heater." Had I listened to his advice we would not have spent the large amount of money on the Hering Furnace that we subsequently did before actually finding out for ourselves that a construction such as described was in fact as much of a water heater as it was a metal heater. Neither would we now be in the electric furnace business. *I am a firm believer in the fact that great progress is made by making mistakes and by encountering difficulties. When mistakes are made or difficulties encountered, there is in the red-blooded man a spirit of determination enflamed; a determination to overcome the obstacles encountered or to correct the error.*

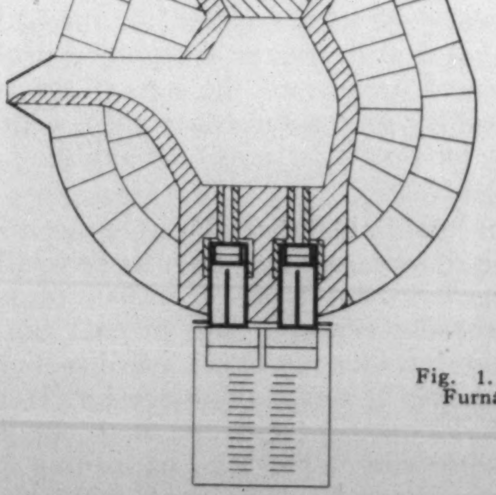


Fig. 1. Hering Electrode Type Furnace—120 KW. Capacity.

Dr. Hering explained to me his law for electrode proportioning and why the losses through the electrodes should not be high. In a two-phase brass furnace, powered with 120 kilowatts and 22,000 amperes passing through the electrodes, we found by actual measurement that 50% of the heat energy was being carried out by the electrode water cooling stream. (Fig. 1)

We tried to overcome the "skin effect" by making the electrodes hollow and filling the hollow space with refractory.

With this type of electrode we were at least able to operate as the heat losses were cut down. The furnace above referred to was equipped with this type of electrode. It can be well imagined what the heat losses must have been in the earlier furnaces.

The second difficulty encountered was that of imbedding these enormous electrodes in refractory material and to prevent the cracking of the refractory due to the unequal thermal expansion of the metallic electrodes as compared with the refractory material in which they were imbedded.

It is not hard to realize the difficulties to be encountered when attempting to imbed metallic electrodes having a diameter in excess of 6 inches and a length of 12 inches in the hearth of a furnace that must be kept metal tight. Strange to say, we did succeed on a number of occasions to the extent of operating furnaces for a period of several weeks before cracking and leakage resulted. It was, of course, not possible to allow a furnace charge to cool to the solidification point after once being started. This inevitably resulted in cracking when the furnace was re-started.

After being brought to a full realization of the problems involved in attempting to produce a commercially practicable furnace of this simple design, I asked Dr. Hering why he did not abandon the use of the electrodes which were the source of all our grief, and continue our experimenting with an induction furnace using the "pinch force" as a means for circulating the molten metal in the resistor. This seemed like a perfectly simple and obvious thing to do; namely, to merely join the two resistors around a magnetized core. That is what we afterwards did, and it was the road that led to success. Dr. Hering explained to me, with much scientific data and many formulae, why this did not seem practical to him. He stated that he had realized such possibility when he applied for his patent and had, therefore, injected some process claims based on the use of circulating metal by means of "pinch pressure." His contention was that the molten metallic circuit, in order to embrace a magnetic core and also a primary coil that must be placed within the loop in order to obtain a satisfactory power factor, would be so long that the metal therein would be volatilized before it reached the bath. He believed also, that a still greater refractory problem would be presented because of the size of the refractory lining necessary to accommodate such a long loop of metal. As he put it, it was like building a window in the furnace.

It was some time after this that Wyatt conceived the idea of the form of resistor loop, now so generally used in the submerged resistor type of furnace of today. Our electric furnace research was at that time, and has ever since been under my executive direction. James R. Wyatt was one of our staff under Dr. Hering during this development period; he had opportunity for closely observing what was happening in all parts of the many furnaces constructed. He also had the particular opportunity of observing the fluid action in the electrodes after they became molten. The electrodes invariably melted back to the point where they were restrained from further melting only by the water cooling. One of the forms of electrode used, as previously stated, was that of a cylinder with a head on it. (Fig 2) The resistor was attached to the middle of the head. I neglected to state previously that we found added to our difficulties the necessity for overcoming the impact of a hot stream of liquid metal resulting due to "pinch pressure". Pinch pressure is effective over the entire length of a resistor, and, therefore, a stream of hot metal is forced in both directions; namely, out of the resistor into the bath and down through the resistor against the electrodes. The washing action of the down flow of hot metal we attempted to overcome by making an electrode of the design to which I have referred; namely, that of a hollow cylinder with a head on it. The hollow cylinder was tightly tamped with refractory material. Notwithstanding this construction of the electrodes which overcame this downward washing action due to "pinch pressure" it was noted that the electrodes still persisted in melting back to a point where further melting was prevented only by the water cooling.

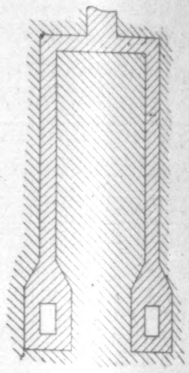


Fig. 2. Hering Electrode Hollow Cylinder Type — Hollow Space Tamped Refractory Material.

Wyatt was delegated to install a small experimental steel melting furnace at the plant of the Firth-Sterling Steel Company in Pittsburgh. This furnace was equipped with electrodes such as I have just described. Molten steel was poured in, and not long after it ran out through the bottom. When the furnace was dismantled and the electrodes examined, Wyatt found that a wall of steel not more than 1/16 of an inch was left on the electrodes. He was no doubt within 1/16 of an inch of his life. Had the steel broken through at that time, there probably would not now be an Ajax-Wyatt Electric Furnace.

After this nearly fatal accident, we decided to conduct some experiments with the hope of discovering the nature of the forces and actions in metallic electrodes. Open forms were molded in ordinary molding sand and the experiments were conducted by using pure lead, not only for the metal of the bath, but also for the electrodes. The design used for the electrodes was that of a stirrup. The resistor was of the usual straight cylindrical shape used in all the experiments. Sufficient hydraulic head was maintained in a crucible to overcome the "pinch pressure" and thus prevent the rupturing of the circuit in the resistor. (Fig. 3) The electrodes soon became molten as they always did, irrespective of our careful proportioning and designing. Considerable banking of the liquid metal in the electrode was observed at the right angle bend in the electrode. At this bend, it must be understood the current flowed through a right angle. As conductors carrying current in like direction attract each other, whereas conductors carrying current in opposite directions repel each other, it will be understood that repulsive action results in such an angular path. Was this action due to backward flow resulting from "pinch effect" in the resistor, or to motor effect?

In order to determine which of these forces was causing this banking of the metal, our next experiment was to duplicate the conditions in the electrode used in the lead melting furnace I have just described.

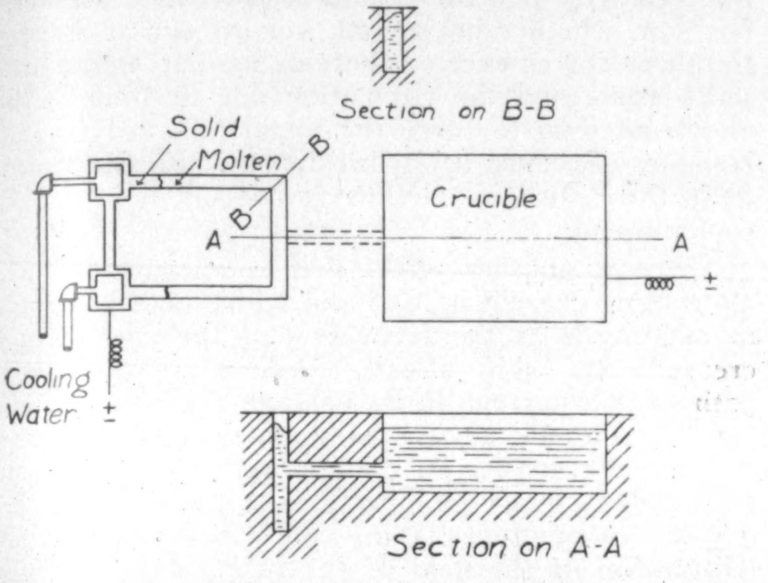


Fig. 3. Electrode form having 90° angle connected with the Hering resistor, and crucible. Decided action of metal on the line BB piling up against outside walls was observed. We questioned if this action was due to backward flow of metal resulting from "pinch force" in resistor, or if it was due to "motor effect."

We made a form duplicating the conditions in the electrode used in the experiment I have just described by maintaining the same cross sectional area and the same current density, also the same angularity for the current path. To this form we attached no resistor and thereby eliminated any effect that might result therefrom. Current was led into this right angled form, and the current density was so chosen that it corresponded with that to be used in electrodes. The power input was not sufficient to melt the metal, so it was melted with a torch. When the current passed through the melted metal the same banking effect at the corner was observed. As this banking effect resulted under the described current conditions which we so proportioned that the "pinch pressure" was negligible, we concluded that the banking was due to motor effect.

To confirm this belief, we conducted an additional experiment by passing power with the same current density through a straight conductor of rectangular cross section. The current density was maintained the same as in the former experiment and was, of course, also not of such magnitude that the metal could be melted by the power input, so was again melted by a torch. Here again, the dimensions of the conductor were such as would be used in electrodes; the "pinch effect" was accordingly again negligible. In this experiment no banking of the liquid metal was observed.

This experiment confirmed our assumption that the banking was due to motor effect, the motor effect resulting because of the angularity of the current path. As this banking action indicated the presence of a force of considerable magnitude, notwithstanding the fact that the dimensions of the molten conductor and current conditions were of electrode proportionings, we at once realized that the force could be exerted with much greater intensity if it resulted under conditions of resistor proportioning.

The next experiment was the first attempt to apply motor force for the circulation of molten metal. It was also the first effort on our part to use the principle of electro-magnetic induction for converting electrical energy into heat energy. In this experiment we used a lead form having the dimensions of an equilateral triangle. (Fig. 4) Two of the legs of the triangle formed the resistor and the third was made of wider dimensions so as to constitute a bath. The magnetic loop of a transformer was made to interlink one of the sides of the leaden triangle and the primary coil was placed upon the magnetic loop outside of the triangle. In this experiment the dimensions of the two legs of the triangle were such that with the density of the induced current flowing therein they soon melted. The heating was continued until the bath too became molten. Observation revealed the fact that there was violent banking and stirring of the metal at the angle opposite the bath, and banking and stirring to a lesser degree at the angles at the bath end. As the angles were all of 60°, motor effect of each of them would necessarily be the same. As the bath was of much greater cross section than the resistors the current density of the current flowing through the bath was very much lower than that flowing through the resistors. This being a fact, the pressure on the bath side of the triangle was relieved.

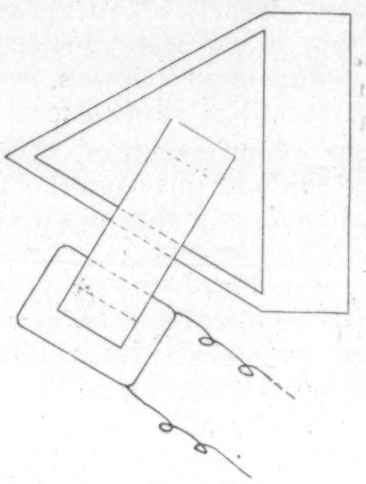


Fig. 4. The first attempt to embody the "motor effect" idea as a means for circulating liquid metal. In this case two legs of the triangle formed the resistor, and the other leg the bath. There was a decided banking effect in the angle farthest from the bath, and banking effect of less magnitude at both angles, which the resistor formed with the bath. In the construction shown there is a transformer, the magnetic loop of which surrounds one leg of the resistor, and the primary coil is placed on one of the legs outside of it.

This experiment indicated clearly that there was an electro-magnetic force exerted at the angles of such magnitude as to offer a practical means other than "pinch pressure" for circulating molten metal. It indicated the possibility of constructing a practical electric melting furnace. This experiment pointed the way not only to a means of circulating molten metal, but also a means for eliminating the troublesome and impractical electrodes of the Hering furnace with which we had previously been experimenting. This was the discovery of James R. Wyatt that led to the development of the now well known Ajax-Wyatt submerged resistor induction furnace.

The induction principle in electric furnace operation was not new in the art at that time. The earliest conception of this idea, I believe, can be credited to E. A. Colby of Newark, who was granted a patent in 1888. DeFerranti in Europe patented the same idea almost simultaneously. Neither of these inventors, however, conceived the idea of a submerged resistor upon which was exerted the hydro-dynamic pressure of a molten bath. Both inventors described the open ring type induction furnace that soon thereafter became well known. In the furnace described by them, the bath of metal constituted a single turn secondary circuit of a stepdown transformer.

A few years after Colby's patent was issued, namely, in 1901, Kjellin in Sweden was melting steel in a furnace of the Colby type. Kjellin's furnace differed from that of Colby in that he placed the primary circuit of the transformer within the secondary loop, and thereby secured the great advantage of a better power factor. The early work of Kjellin led to the development of the larger open ring type furnaces used in the steel industry. Many modifications of the original Colby furnace have been patented and a number of these, particularly the multiple loop and unit hearth type such as the Röchling-Rodenhauser came into extended use. Nearly all of these furnaces have, however, of late years been replaced by furnaces of other types. The main reasons for the abandonment of this type are the following:

High initial cost due to the requirement of very low frequency power, high upkeep and uncertainty of operation due to refractory difficulties; also unsatisfactory dimensions of the bath and necessity for retaining in the furnace a residual molten bath. A few open ring type furnaces are still in operation, because much ingenious effort has been expended in attempting to overcome the inherent difficulties.

Having established the fact that the induction principle could be taken advantage of, thereby eliminating the troublesome electrodes, we next conducted experiments to determine if it was possible to use "pinch pressure" to circulate the molten metal in the resistor of an induction furnace. With this objective in mind we next made a sand form using the same dimensions for the resistor and the bath as we used in the previously described experiment, using also the same current density. The only difference in the two experiments was that in this one in the place of the angular resistor we used one having uniform cross section and of semi-circular form. Power was carefully applied until the lead in the resistor and the bath became thoroughly molten. We noted that there was decided banking and overheating of the liquid metal at the point farthest removed from the bath. There was a decided choking effect at the points where the semi-circular resistor loop met the bath, indicating that the motor force due to the angularity at these two points was greater than the "pinch pressure" forcing the liquid metal out of the resistor.

These experiments rather confirmed Dr. Hering's explanation and prophecy that I have referred to before. Dr. Hering contended that the metal in such a resistor would not free itself by "pinch pressure" and that overheating would result. He unfortunately did not go far enough in his reasoning to suggest ways and means for overcoming this difficulty. A practical induction furnace using "pinch pressure" as the force for circulating metal in the resistor has been designed; I will refer to it later.

The next experiment led to the form of resistor that is now the standard form used in the Ajax-Wyatt Furnace. It is a resistor with an acute angle at a point farthest removed from the bath and with obtuse angles or a flaring mouth at the end of the resistor where it joins the bath. This resistor was so designed with the specific object in view of obtaining maximum pressure due to motor effect at the root of the resistor and minimum pressure due to motor effect at the two points where the resistor joins the bath. With a resistor of this type properly proportioned there can be produced electro-dynamic pressure of such magnitude that very energetic circulation of the metal results. As in all pump constructions back pressure should be avoided, just so the back pressure due to electro-dynamic force within the path of the current flow at more than one point should be avoided. To avoid back pressure the resistors are purposely flared at the mouth and in this way it is possible to circulate the metal freely in the resistor. The circulating stream of metal from the resistor easily enters the bath and in turn exerts the circulating influence upon it. In a resistor so proportioned in respect to the current applied, pinch pressure must necessarily exist, also Joule effect as circulating influences. By placing such a resistor in a submerged position, whether horizontal, vertical, or at an angle, the three forces exerted therein; namely, motor force, pinch force and the circulation due to Joule or heat effect, all tend to force the metal outward from the resistor. Because of hydro-dynamic pressure of the bath, the heated metal thus forced out is replaced by cooler metal.

There is another effect that is encountered when alternating current is used and which becomes greater in magnitude as the frequency of the current is increased; viz, skin effect. Skin effect distorts the path of the current in its passage through the resistor. It thereby shifts the magnetic field, increases the current density in certain parts of the resistor, and leads to many complications that upset the mathematical calculations taking the same into account. The action of the field of the primary circuit acting on the field of the secondary circuit also distorts the current path.

The dimensioning of resistors requires a knowledge of the resistivity of the metal in its liquid form. The resistivity as determined under direct current conditions varies widely with the resistivity as determined under alternating current conditions. The manifestation of skin effect which causes the current to flow only in a portion of the conductor explains this. As Dr. Northrup had, as I have previously stated, worked out the formula for the quantitative determination of pressure due to pinch effect, we delegated to him the problem of working out the formula for pressure due to motor effect, and also the combined pressures due to motor effect and pinch effect, as they co-existed in the Ajax-Wyatt furnace.

The following is a summary of his conclusions. In the Ajax-Wyatt furnace hydro-dynamical forces of considerable magnitude are developed which give rise to fluid motion, particularly at apex of the V shaped resistor used. Furthermore, the upright position occupied by the furnace effectually prevents rupture of the circuit by internal pressure forces. Both motor effect and internal pressure effect increase with the square of the current and thus any increase in current will cause these two effects to increase in the same ratio.

Dr. Northrup did not take into consideration, in arriving at his mathematical conclusions, the two following disturbing influences:

1. Skin effect;
2. Distortion of current path due to action of primary field on secondary field.

When these are taken into consideration the mathematical relationship becomes so extremely complicated that there is only one sure way for determining the dimensions and current relationships in the designing of a resistor that will operate with maximum efficiency; viz, the method of cut and try after the best mathematical calculations have been made. This has been the method we have always followed.

As is usually the case when an inventor believes himself to be the first in the field, a complete search of the patent office records of the world revealed a patent in anticipation. We found, several years after the granting of the Wyatt patent, and after we had spent a considerable sum of money in developing the invention, that a patent had been issued about ten years prior to Mr. Charles P. Schneider, President of the Creusot Steel Works of France. The Schneider patent was the first patent covering an induction furnace having a submerged resistor, and in which the bath of metal exerted hydraulic pressure upon the molten metal of the resistor. In the Schneider furnace the molten resistor constituted the secondary loop of a step down transformer. Schneider had no idea, however, of utilizing the pinch force for circulating the metal in the resistor. His patent described the circulation as being entirely due to thermal effect. To accomplish this the resistor was placed in a substantially horizontal position, and its connections with the molten bath were at different levels. Due to the difference in levels, Schneider concluded that the hot metal from the resistor would flow out at the top level, while the cooler metal would have an inward flow at the bottom. The Schneider furnace operation is based upon the principle of a hot water heater with its attached circulatory system.

Schneider, at that time, was no doubt unfamiliar with pinch force. As I have previously stated, the constriction in the diameter of a molten conductor through which a current of high density is passed, was accidentally discovered by Dr. Hering in 1909; viz, the "pinch effect." This discovery was made about five years after the issuing date of the Schneider patent.

Some experiments were made in France with the furnace described by Schneider; they were, however, soon abandoned because the circulation in the resistor was of such a sluggish nature that the furnace was impractical. The melted metal remained in the resistors for such a period of time that it became overheated and the refractory in which it was held was soon destroyed due to fusion.

The actual dimensions and current relationship as used by Schneider have since been calculated using the "pinch effect" formula and it has been found that "pinch effect" of very small magnitude existed. The exertion of pinch force is naturally one of degree. It must necessarily be present in all molten resistors. The magnitude of the pinch force may, however, as was true in the Schneider furnace, be of such small degree that it has very little, if any, effectiveness in producing circulation. Had Schneider understood pinch force he would either have decreased the diameter of his resistors using the same current input, or he would have greatly increased the current input. This means that the current density in the Schneider resistors was so small that pinch force effective for circulation did not exist. Pinch force of small magnitude was present in the Schneider resistors but not recognized by him.

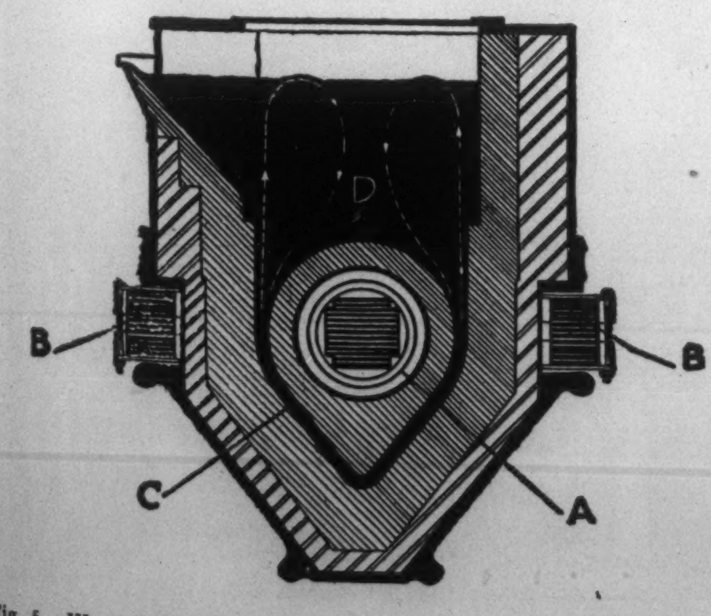


Fig. 5. Wyatt Induction Furnace using V-form secondary. Dotted lines indicate direction of circulation.

As Schneider was the first to conceive the idea of an enclosed and submerged resistor upon which was maintained the hydro-dynamic pressure of a bath of liquid metal, and conceived also the idea that circulation of the metal within the resistor was an essential for success he, therefore, secured a very broad patent. The first claim of his patent reads as follows:

> "In combination a chamber for holding molten metal, one or more pipes communicating with said chamber so constructed as to permit circulation of molten metal, an iron core encircling said pipe or pipes and means for producing lines of force in said core."

It is quite evident that a furnace, irrespective of its specific design if it uses a submerged resistor, a hydraulic head of metal and means for circulating the metal in the resistor, infringes on this broad patent of Schneider. Realizing this fact, we purchased the Schneider U. S. A. patents. Our field was now clear to build furnaces with submerged resistors having the metal therein more vigorously circulated than was possible under the Schneider invention of using thermal effect alone.

Three methods for producing active and energetic circulation such as required in a successful furnace may be used:

1. Motor effect, resulting from the action of the field of one leg of a resistor upon the other. This is accomplished by the simple means of a return bend resistor having an acute angle such as used in the Ajax-Wyatt Furnace.
2. The reaction between the field of a coil constituting the primary of the furnace transformer upon the field of a liquid metal secondary loop of the furnace transformer. This is accomplished by placing the primary coil in an eccentric position in respect to the secondary loop.
3. A third method is to constrict the diameter of the molten metal in the resistor at some point removed from the bath. By this means maximum pinch pressure is exerted at such point, thereby causing circulation.

Motor force is a repulsive force. The metal, when acted upon by this force, is consequently repelled to the far side of the channel in which it is contained. In this case the cooler metal by reason of hydrodynamic pressure flows in on the near side of the channel to replace the expelled metal. (Fig. 5)

When the pinch force alone is used for circulating, heated metal is forced out from the central portion of the molten resistor and flows in at the outer diameter thereof. These forces cannot act in an entirely undisturbed manner. They are manifested to more or less extent in the same resistor. (Fig. 6) Fortunately, the forces exerted are such that they all tend to expel the heated metal from the resistor and

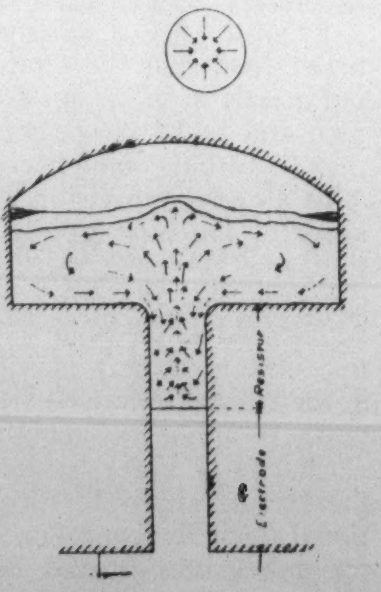


Fig. 6. Diagram illustrating the action of "pinch force" as applied in the Hering Electrode Type Furnace.

through hydro-dynamic pressure the expelled metal is replaced. In the Wyatt furnace, with the return bend or V form resistor, the predominant force is motor force resulting from the action of the field of one leg of the resistor upon the field of the other leg. There is also expulsion of the metal due to pinch force and a tendency of the metal to rise because of thermal effect. In addition, there may be circulation resulting from convection due to gassing of some volatile constituent of the metal in the resistor. There is also the repelling action of the field of the primary circuit upon the field of the secondary circuit.

In the second case, if a U form resistor of uniform cross section is used and the primary of the transformer is placed in an eccentric relationship thereto, the motor force of primary upon secondary may produce the dominating pressure and pinch pressure is of secondary importance. Thermal effect and convection effect also exert their advantageous influence in circulating the metal upward. (Fig. 7)

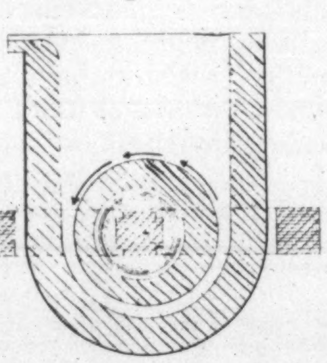


Fig. 7. Wyatt furnace using U-form secondary and primary in eccentric relationship thereto. Arrows indicate direction of circulation.

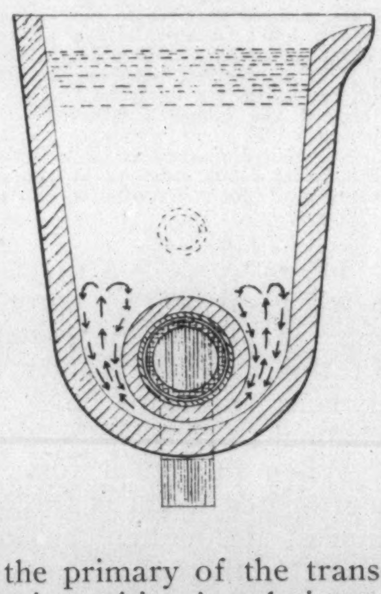


Fig. 8. Foley Type Furnace—U-form secondary, primary in concentric relationship thereto and constriction of secondary path at bottom; viz., maximum pinch pressure at bottom.

In the third case, where the primary of the transformer is placed in a concentric position in relation to the secondary loop and a constriction of the section of the secondary loop is provided, then the predominating pressure is that of pinch force at such constricted section. The motor effect of secondary upon secondary is in this case practically nil. (Fig. 8)

From the above statement of facts it will be readily understood that the study of the circulation of molten metals in induction furnaces is a complicated subject, and as I have previously stated there is the further disturbing influence of skin effect.

In all cases provision must be made to free the resistor of the very rapidly heated metal and to replace the same by colder metal. In order to effectively accomplish this the force causing the circulation must be relieved at the point of entry to the bath. To sum up, there must be a maximum pressure at some point in the resistor removed from the bath, and a minimum pressure at the two points of entry into the bath.

Charles B. Foley, at the time we were working with the Hering electrode furnace at the plant of the National Cash Register Co., conceived the idea of a submerged resistor furnace operated with pinch pressure. Foley, I do not believe knew that there were process claims in the original Hering patent that antedated him. He built a small model of a furnace with a resistor loop of uniform cross section throughout and with the primary of the transformer in a concentric position in respect to the secondary, and no provision for relieving the pressure at the entrance to the bath. Overheating in the resistor due to its great length and the backpressure at the point where it entered the bath, was the cause of the failure of this furnace. Foley probably realized this and then conceived the idea of constricting the cross section of the secondary loop at a point removed from the bath and flaring the mouths of same. Foley filed a patent application covering this idea in 1914. He afterward secured backers who backed him up to the extent of $130,000.00 in attempting to build a practical working furnace. Foley evidently did not have a sufficiently clear understanding of all the intricate problems involved, because further work was abandoned at the plant where this development was carried on, and Ajax-Wyatt furnaces installed.

Through unintelligent handling of his patent application in the Patent Office, Foley did not apply for the broad claims covering his structure to which he was entitled. In 1926 his application filed in 1914 was still in the Patent Office. At that time we purchased the total stock of Charles B. Foley, Inc., a company owning the many Foley patents. We had but one object in mind in buying that company; namely, the acquisition of the early Foley patent application referred to. After securing ownership of the same we then prepared a claim as follows:

> "The method of heating and stirring the pool of molten metal in an electric induction furnace which comprises forming by suitable refractory walls a pool of molten metal and a loop of molten metal connected with the bottom of the pool, heating the metal by induced currents and simultaneously driving the hot metal from the loop by the application of electromagnetic pressure acting with maximum intensity on the metal in the outer or lower part of the loop."

Foley, through his disclosures in the original patent application, was clearly entitled to such a claim, and the only patents at that time ahead of him were those granted to Schneider and to Hering. Such a claim would underlie the claims of the Wyatt patent. It describes an improvement over the Hering patent that makes the application of pinch pressure effective and practical for circulating molten metal in the resistor of an induction furnace. The patent was finally issued on August 9, 1927, thus affording patent protection covering a practical submerged resistor induction furnace until 1944.

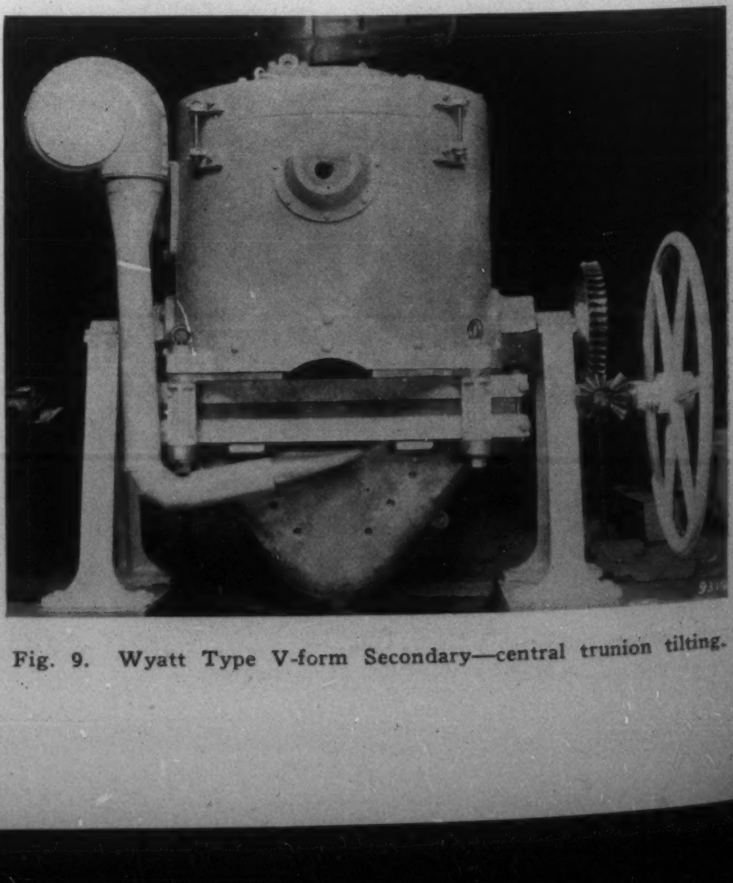


Fig. 9. Wyatt Type V-form Secondary—central trunion tilting.

I will not present data to indicate operating performance of the submerged resistor type furnaces as compared with fuel furnaces, because this ground has been frequently covered in previous papers. Neither will I compare the submerged resistor furnace with other types of electric furnaces, as this ground also has been covered.

From the electrical standpoint, the submerged resistor furnace compares favorably with the highly developed transformer art. There is an electrical efficiency of 95 plus, a power factor of 70 to 80% and thermal efficiency 80 plus. High as these figures are, we are still conducting researches for the purpose of still further improving them.

The outstanding problem, and the one giving us by far the greatest difficulties, has been in securing dependable refractory linings to exhibit long life.

The alloy for which there was the greatest demand for an improved melting method, and the metal most extensively used, was brass; namely, the copper-zinc alloys. Yellow brass is cast at a relatively low temperature and it has a relatively low lead content. These two facts were indeed fortunate for us, because it made possible the use of a lining material of the ordinary fire clay nature. We had no difficulty in very early finding a perfectly satisfactory material. We did, however, at first experience some difficulties in producing linings because of the rather intricate form required for the internal structure of the furnace. As long as the lead content was low, namely, below 5%, no slagging action with the refractory resulted. The one difficulty we had to overcome was that of cracking. Cracking might result either from temperature shock or strains resulting from contraction or expansion.

To adequately describe the experiments made to find a means for preventing cracking of refractory linings would require more space than is at my disposal. I will consequently refer only briefly to the two methods of lining now used with complete success; first, use of a pre-formed and pre-fired refractory block; second, tamping about a complete hollow secondary wooden form. In the hollow wooden space resistor ribbons are placed for the dual purpose of charring the wooden form when they are inductively heated and also for drying the lining. After charring the wooden form is then burned out by using a torch, thus forming the resistor channel. The upper or crucible portion of the furnace is either rammed in or is built up of sectional shapes, or a continuous cylindrical form. I have here described in a few words the results of years of research in perfecting refractory linings for the Ajax-Wyatt furnace, costing upwards of $50,000. Space will not permit me to go into further details; a book on the subject could be written.

Coupled with the problem of producing a complete lining that would be metal tight, there was also the problem of finding satisfactory refractory materials that could be used in connection with the various metals to be melted. The search for the most satisfactory materials has practically covered the entire field of refractories. As I have stated previously in my paper, for yellow brass melting we were fortunate in almost immediately finding a suitable material. The ordinary clay base refractories are practically all by degrees satisfactory. The only problem has been to find the material that would give the best service. These linings were from the start sufficiently serviceable to be highly practical and commercial. At the present time lining life represented by 2,000,000 lbs. is about the average, and the prize performance has been 30,000,000 lbs. on a lining that was in use for a period of nearly seven years. As the linings are relatively inexpensive, the cost per ton can hardly be figured.

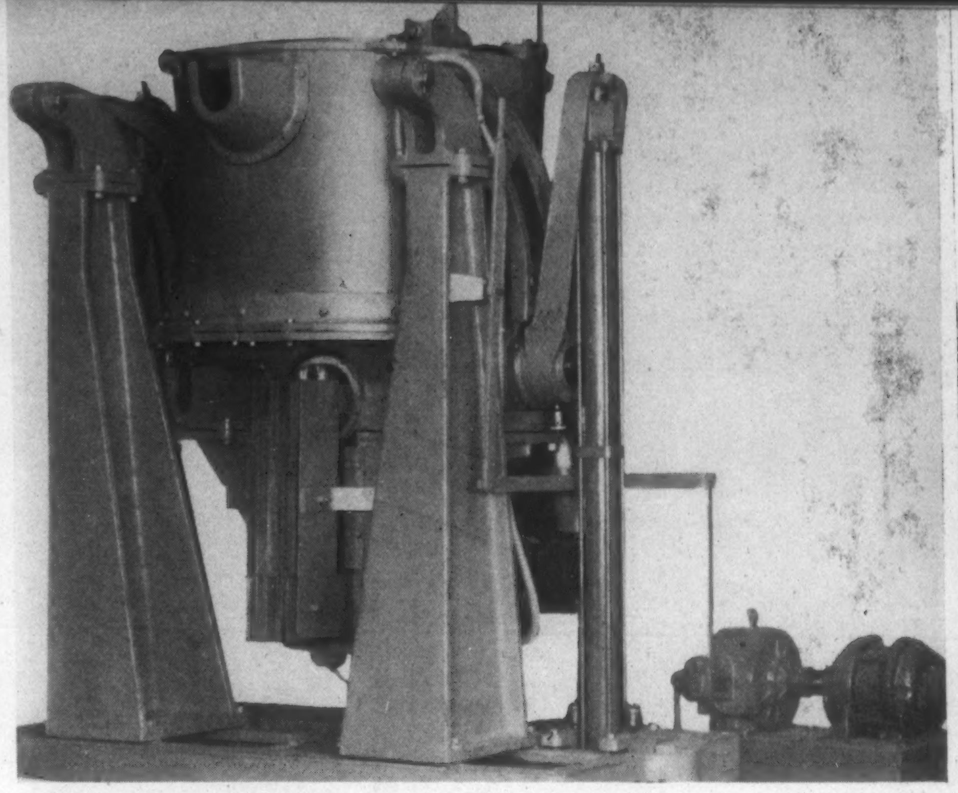


Fig. 10. Wyatt Type 120 KW.—latest design.

These clay linings will satisfactorily handle metal containing up to about 5% of lead, but when this amount is exceeded, the linings are fused by combining with the lead oxide, resulting through oxidation of the lead in the metal. When the fusion becomes sufficiently extensive the inductor channel is clogged and the furnace becomes inoperative.

We also have had difficulty of finding refractories that would stand up under high temperature necessary for casting the high copper content alloys. For use in melting these metals the clay base refractories are not suitable, and it became necessary to experiment with the refractories of a more basic nature. High silica linings are not satisfactory, because of the chemical attack. Unfortunately, with these high melting point refractories it was not possible to use a bond of clay material. In the absence of clay material there is an absence of plasticity essential for preventing cracking. Although quite a number of materials are satisfactory so far as their temperature and corrosion resistance is concerned, the problem has been to find a satisfactory bond to prevent cracking, and also to prevent seepage of metal through the pores. Assisting us in our problem we have had the cooperation, at one time or another, of practically all the leading refractory manufacturers in the country. Magnesite and mixtures of magnesite and alumina have been found to be quite satisfactory for the high melting point metals and alloys, also those of high lead content.

Researches on this one phase of the refractory problem were extended over a period of about 10 years, and as stated have been very costly. It is an unfortunate fact that tests of linings are absolutely worthless if made under other than service conditions. Service tests are time-consuming. It has often been found that lining of some particular refractory in one or more furnaces gave excellent lining life, only to be followed by an epidemic of failures. Because of this fact, it is only after the satisfactory and consistent performance of many linings that a conclusion as to its merits can be drawn.

As is always the case in developing a structure such as the Ajax-Wyatt furnace, improvements never

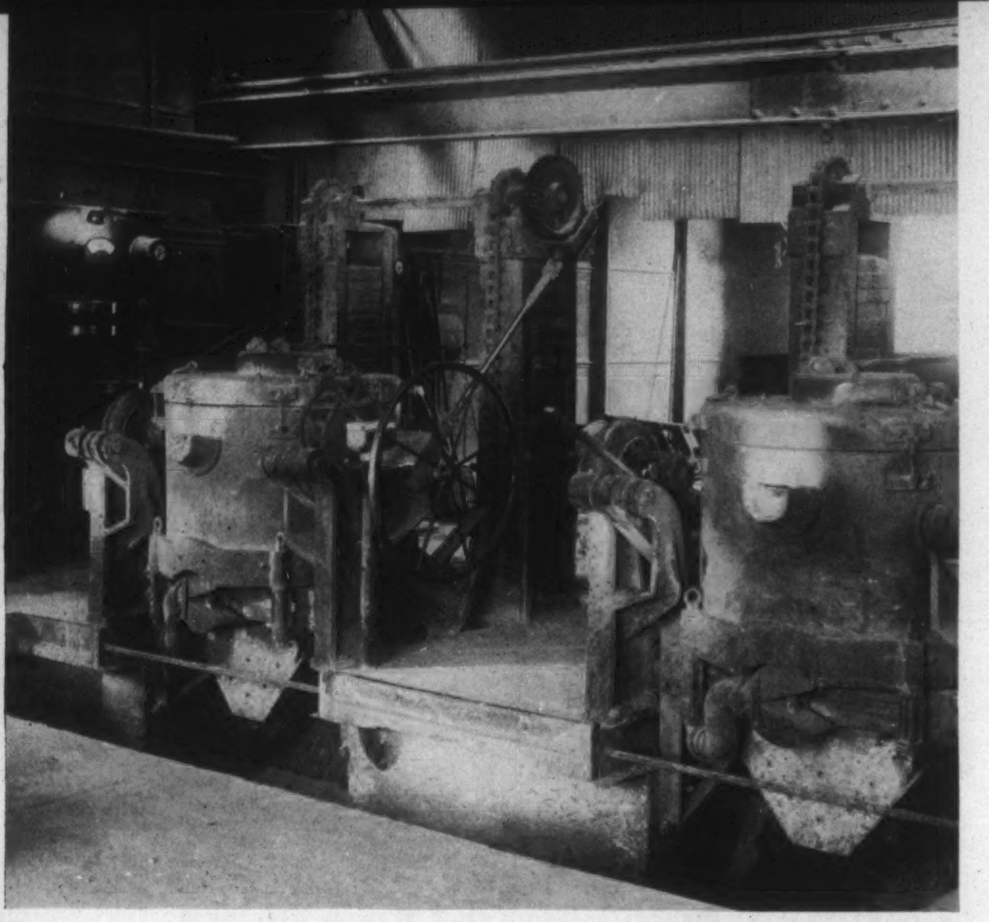


Fig. 11. Typical installation two units Ajax-Wyatt furnaces.

cease. Many improvements have been made in coil structure, transformer design, mechanical construction, etc. Efforts are still being made and will no doubt continue indefinitely in this direction. (Fig. 9)

It is seldom that a new equipment has been so universally adopted. Statistics indicate that upwards of 95% of the tonnage of the wrought alloys at present produced in this country is melted in Ajax-Wyatt furnaces. The furnace was not introduced into Europe until about ten years ago, but there also the adoption has been quite as revolutionary, and in a very short time will no doubt equal the record in this country. On January 1, 1934, there were 824 of these furnaces in use throughout the world, 468 furnaces in this country, and 356 abroad. It is estimated that the daily capacity of all furnaces installed is approximately 10,000,000 lbs. per day.

Because of the high operating efficiency of this furnace it has also been installed in foundries in which the operating conditions are not such as to require frequent changes of mixtures or requiring a class of mixtures that are not convertible from the liquid heel that must always be retained in the furnace.

The major problems now having our attention are the designing of larger furnaces; namely, up to 240 kw. Recently several furnaces of an entirely new design with rating of 120 kw. have been installed. (Fig. 10)

In Europe Ajax-Wyatt furnaces are used with a cupola in a duplexing capacity for super-heating molten iron and for mixing therewith alloying metals such as nickel, chromium, etc.

The first commercial furnace of the Ajax-Wyatt type was installed at the plant of the Bridgeport Brass Company in the latter part of 1916. This was a furnace of 30 kw. capacity. The next installation was a 30 kw. furnace at the plant of The American Brass Company in January, 1917. The first installation of a 60 kw. furnace was made at The American Brass Co. in July of that year. This type of furnace was soon thereafter adopted by these two companies as a standard melting unit, and I wish at this time to express may thanks and appreciation to Mr. William R. Webster of the Bridgeport Brass Company and to Messrs. J. R. Coe and the late William H. Bassett of The American Brass Company, whose foresight and enthusiasm, coupled with their coöperation in the early stages, was of great benefit in the development of the furnace I have just described.

The following table indicates the number of furnaces and the kilowatt capacity in use at the end of each year, 1918 to 1934 inclusive:

Year	No. of Furnaces	kw.
1918	28	1,400
1919	72	3,510
1920	96	5,690
1921	178	10,500
1922	211	11,805
1923	271	15,865
1924	368	21,715
1925	405	23,925
1926	487	28,930
1927	499	29,785
1928	599	37,340
1929	636	40,345
1930	802	53,620
1931	814	54,480
1932	815	54,560
1933	818	54,785
1934	824	55,190
	7,923 Furnace Years	503.445 kw. Years

The average number of furnaces in use during the seventeen-year period is 466 and the average kilowatt connected load 29,614. The average daily output per furnace is approximately 5 tons, or 1500 tons per year per furnace, estimating 300 days per year operation. The total capacity, therefore, of the furnaces in use is approximately 700,000 tons of metal melted per year. In seventeen years these furnaces would have a total productive capacity of 11,900,000 tons. It is believed to be quite conservative to estimate that these furnaces, during the period of installation, have operated at least at 60% of capacity. On the basis of this estimate, the output is 7,140,000 tons. The saving in operating cost over the equipment that has been replaced is quite in excess of $5.00 per ton. Using the $5.00 figure per ton the saving effected during the seventeen-year period has been $35,700,000.

The average metal loss under the old crucible practice has been authoritatively given as 2½%. The metal loss in the Ajax-Wyatt furnace is approximately 1%. There is, therefore, from 1 to 1½% of metal going into the finished product instead of by-products, only part of which may afterwards be reclaimed. Since nearly 12,000,000 tons of metal has been melted in the Ajax-Wyatt furnace since its inception, using the 1% figure as actual metal loss and an average metal price of 5 cents a pound (mostly zinc but some copper and other metals) the metal loss figure becomes $12,000,000. This, added to the above, gives a grand total $47,700,000 representing the saving resulting due to the installation of Ajax-Wyatt furnaces. It is realized, of course, that but a small portion of this saving has gone into the pockets of the furnace user, except in the case of the first furnaces installed. It has been stated that some of the first installations were amortized out of savings within a year. As more and more of these furnaces came into use the furnace user, of course, enjoyed correspondingly less of the saving effected. It was, however, necessary for such furnaces to be installed in order to meet the production cost of the mills already equipped. The saving, as is generally true except in cases where equipment is under monopolistic control, is passed on to the ultimate consumer of the product; namely, it goes toward elevating the standard of living of the masses. The above figures are presented for the purpose of illustrating that in this particular Case History of Research, the return has been great. As has been previously stated, the Ajax-Wyatt furnaces have replaced in excess of 95% of the crucible type furnaces previously used in the brass mill industry.

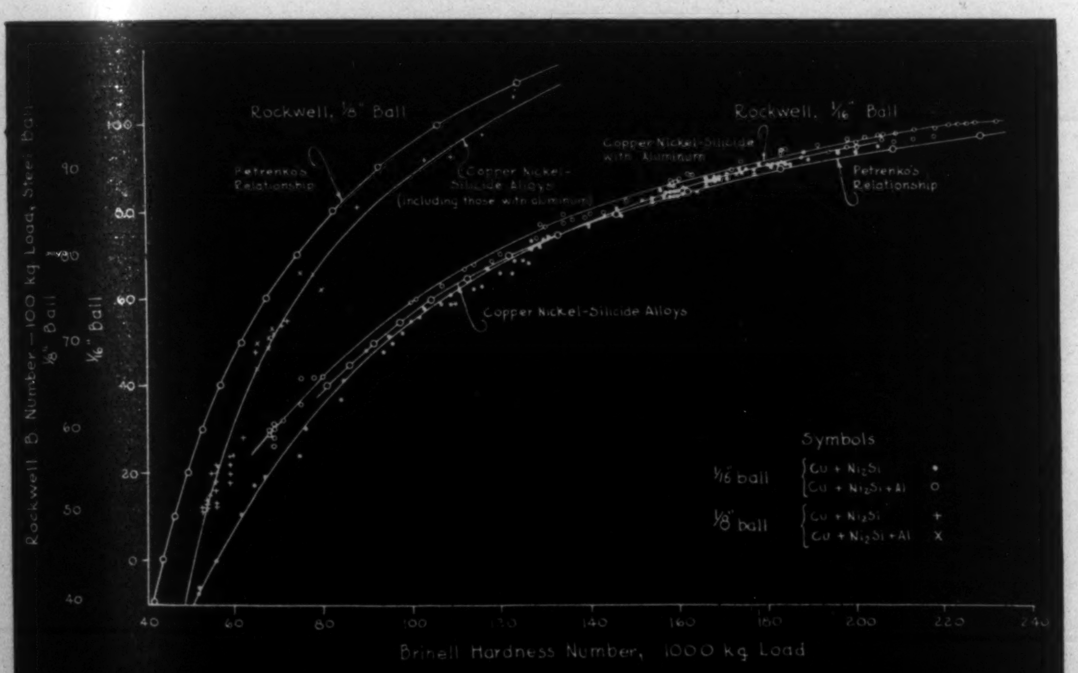
The Age-Hardening Characteristics of Some Copper-Nickel-Silicon Alloys

By Bruce W. Gonser and L. R. van Wert*

AMONG the various non-ferrous alloys which show exceptional age-hardening properties are certain copper base alloys which contain nickel and silicon in such proportion that nickel silicide may be formed as the hardening constituent. M. G. Corson[1] was first to call full attention to the aging properties of these and associated silicide alloys. Other investigators as W. H. Bassett,[2] J. L. Gregg,[3] W. C. Ellis and E. E. Schumacher,[4, 5] and Wilson, Silliman and Little[6] have published additional information supplementing Corson's work or giving notes on certain practical applications or physical characteristics. This investigation was undertaken to obtain more complete information on the general age-hardening characteristics. It covered—first, the effects of such variables as time, temperature, and cold work both in the solution anneal and the precipitation or age-hardening treatment; second, the changes during aging as obtained by twisting, conductivity, dilatometric, metallographic and X-ray tests.

The 3 alloys used in this experimental work were obtained through the courtesy of the American Brass Company. As received, they were in the form of ¾" rod. Previous treatment had consisted in hot rolling the cast alloy to ⅞" diameter rod, quenching from 900-950° C. and cold rolling or drawing to the ¾" size. This gave material hardened by work but not aged by heat treatment. Analyses of the 3 alloys follow in Table 1.

Fig. 1. Rockwell B—Brinell Relationship.



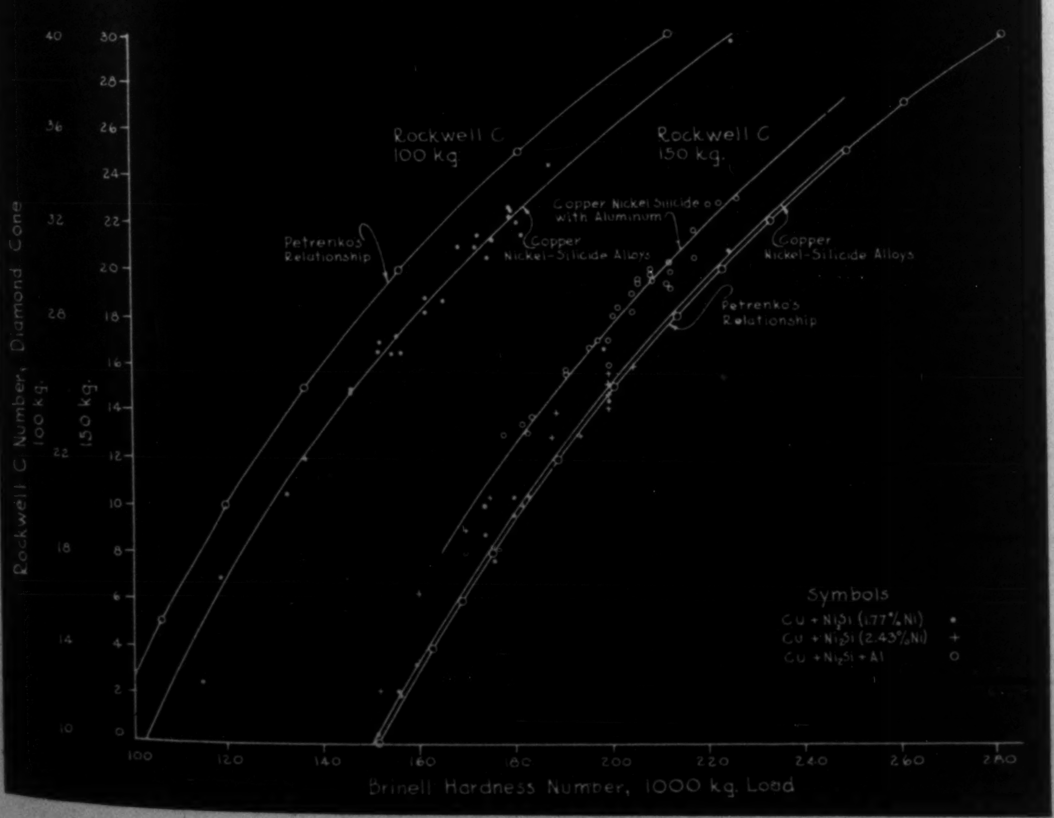


Fig. 2. Rockwell C—Brinell Relationship.

IN view of the interest in precipitation-hardened copper-base alloys here and abroad and especially in view of the foreign discussion of the "Kunial" alloys in general terms, without specific information, this detailed study of some alloys of that general class is particularly opportune.

Table 1. Alloy Analyses

	Series A	Series B	Series C
Copper, %	89.29	96.81	97.78
Nickel, %	4.42	2.43	1.77
Silicon, %	0.98	0.57	0.40
Aluminum, %	5.31	nil	nil
Calc. Ni_2Si, %	5.07	2.95	2.08

Results of physical tests on samples of Series A and B as received are given in Table 2.

Table 2. Physical Properties.

	Series A	Series B
Size tested, inches	0.620	0.619
Yield Point, lbs./in.,^{2} 0.75 Div.	69,900	53,700
Tensile Strength, lbs./in.^{2}	86,200	56,200
Elongation in 2 in., %	41.5	25.5
Reduction in Area, %	63.0	83.3
Brinell Number, 1000 kg.	167.6	107.4

Changes in hardness were taken as the measure of the physical change undergone during the aging treatment. Hardness tests could be quickly and accurately made with the consumption of a minimum of material. In general, ½" sections from the ¾" diameter rod were sufficient for test specimens.

Both the Brinell and Rockwell machines were used to measure hardness.

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*Lecturer on Metallurgy, Harvard University.

Fig. 3. Solution Annealing Treatment. Series C Copper-Nickel-Silicon Alloy. Effect of Temperature on Hardness; One Hour Treatment.

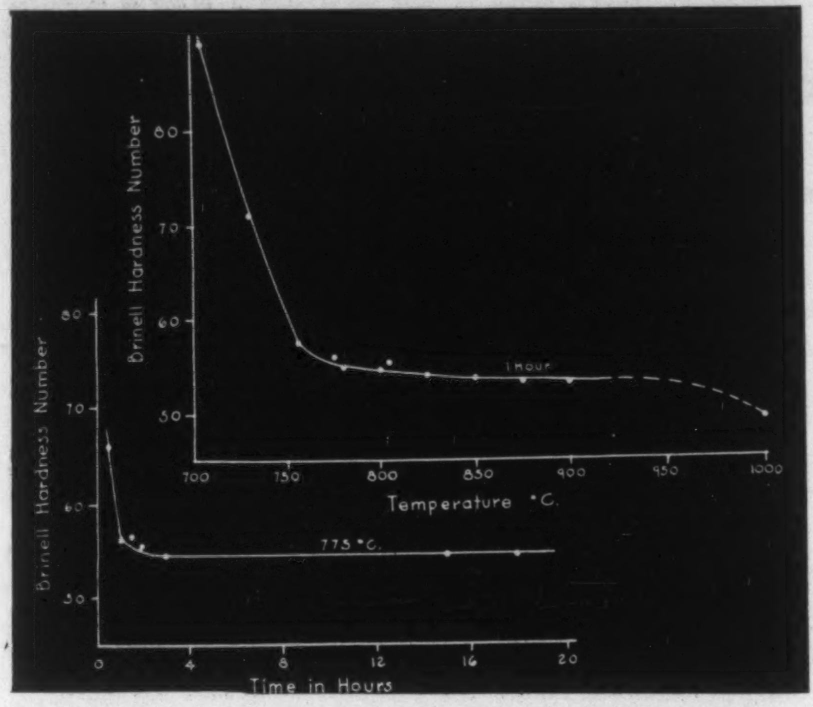


Fig. 4. Solution Annealing Treatment. Series C Copper-Nickel-Silicon Alloy. Effect on Hardness of Heating at 775° C.

More Rockwell tests could be made on a single specimen and higher accuracy secured, especially on comparatively hard material. Because of the wide range in hardness values from the solution annealed to the fully hardened state, however, it was necessary to use 3 different Rockwell scales. It was consequently considered desirable in order to avoid confusion when plotting or tabulating results to use only the 1000 kg., 10 mm. ball, Brinell scale. Rockwell values were converted to the Brinell scale by means of the empirical curves shown in Figs. 1 and 2. Petrenko's[7] Rockwell-Brinell relationships as obtained empirically from testing a wide variety of non-ferrous metals and alloys are also given in these curves as a general guide for comparison.

The Solution Anneal

The purpose of the solution anneal is to get the hardening constituent or solute entirely into solid solution and overcome work strains and distortion. This homogenizing treatment is, of course, followed by quenching to obtain a supersaturated solid solution—the foundation of subsequent hardening by heat treatment, cold work or a combination of both. Various tests were made to investigate factors controlling this preparatory treatment especially in regard to their effect on subsequent age-hardening. These solution annealing tests were made by heating uncovered ½" sections of the alloy for the desired time in a Westinghouse automatic electric muffle furnace followed by quenching in cold water.

Figs. 3 and 4 are typical of the curves obtained to show the rate at which complete softening is obtained from Series C alloy. A practical standard solution annealing treatment of one hour at 775° C. was adopted.

Similar curves showing rate and degree of softening for the Series A alloy containing aluminum are given in Figs. 5 and 6. An annealing treatment of 2 hours at 900° C. was adopted for this alloy. One hour of treatment at 800° or more was sufficient to obtain complete softness for Series B alloy.

The gradual softening below normal hardness when the Series B or C alloy is heated at very high temperatures may be ascribed to grain growth rather than to any increased solubility. Series A alloy containing aluminum was found to be much more stable at high temperatures. Above 1000° a sharp increase in hardness occurs, however. This may be due to oxygen absorption.

Effect of Solution Anneal on Final Hardness by Aging

Alloy samples which had been given the solution annealing treatment under various conditions of time and temperature were given an age-hardening treatment of 2 hours at 500°.

Table 3. Effect of Temperature of Solution Anneal on Hardness Afte Age-hardening.

Solution anneal of 1 hour; precipitation treatment of 2 hours at 500° C.

Series C Alloy

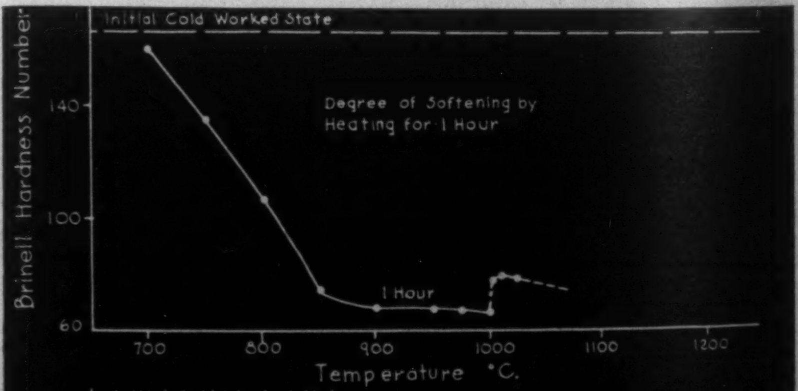
Solution Anneal °C.	Solution Anneal Brinell	After Precipitation Treatment, Brinell
730	80	180
775	56	175
800	54	174
825	54	173
850	54	172
875	53	169
900	53.5	170
1000	49.5	167
Series A Alloy		
850	74.5	208
900	68	207
950	68	206
975	67	210
1000	67	215
1015	79	198
1025	78	194

Table 4. Effect of Quenching Conditions. Series C Alloy

Quenched after 1 hr. at 800° C. Age-hardened for 2 hrs. at 500° C.

Quenching Medium	Brinell	After Age-hardening Brinell
Ice water	55	172.5
Water, room temp.	54	173.5
Boiling water	54	173
Oil	54.5	172
Air, room temp.	56	173

Fig. 5. Solution Annealing Treatment. Series A Copper-Nickel-Silicon Alloy. Effect of Temperature on Hardness; One Hour Treatment.



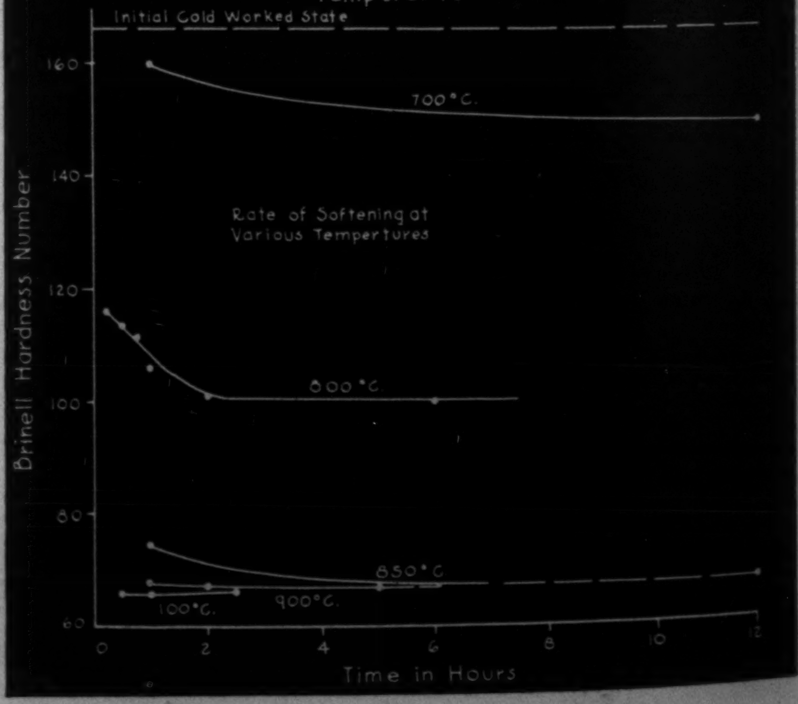


Fig. 6. Solution Annealing Treatment. Series A Copper-Nickel-Silicon Alloy. Effect of Treatment Duration on Hardness; Various Temperatures.

While not the best treatment for maximum hardness the results were directly comparable.

Varying the time of the solution anneal from 0.5 to 18 hours at 775° had no marked effect on hardness gained by subsequent age-hardening of Series C alloy. Increasing the temperature of the solution anneal up to 1000° gives somewhat lower final hardness values, as shown in Table 3, but the gain in hardness by aging remains practically constant. As in all these tests the final hardness should be considered as the net effect of structural changes due to aging and to changes in grain size.

With Series A alloy containing aluminum there was no marked effect of time or temperature of the solution anneal upon final hardness by subsequent age-hardening. When quenched above 1000°, however, marked irregularities were observed in the response to age-hardening of all the alloys. The hardness after age-hardening decreased rapidly as the quenching temperature approached and entered the melting range. This loss in final hardness from an excessively high temperature solution anneal was not nearly as great with the alloy containing aluminum—a further indication of its greater stability.

Effect of Quenching Conditions

To determine the sensitivity of age-hardening to changes in the rate of quenching of small specimens various quenching media were used with results given in Table 4.

Practically no difference in hardness after quenching and no difference in final hardness after aging was found. This pertains, of course, only to small specimens (½" sections of ¾" rod). However, it is evident that the alloy is not highly sensitive to such quenching conditions.

As with duralumin and certain other alloys it is probable that a brief "period of incubation" ensues between the condition of complete solid solution and point where atomic migration reaches a stage which shows external change. It is conceivable that this incubation period would give time for air cooling of relatively small sections of this alloy before any appreciable precipitation or hardness change took place. The relatively high temperature required for rapid aging also favors complete retention of the solute even on air cooling.

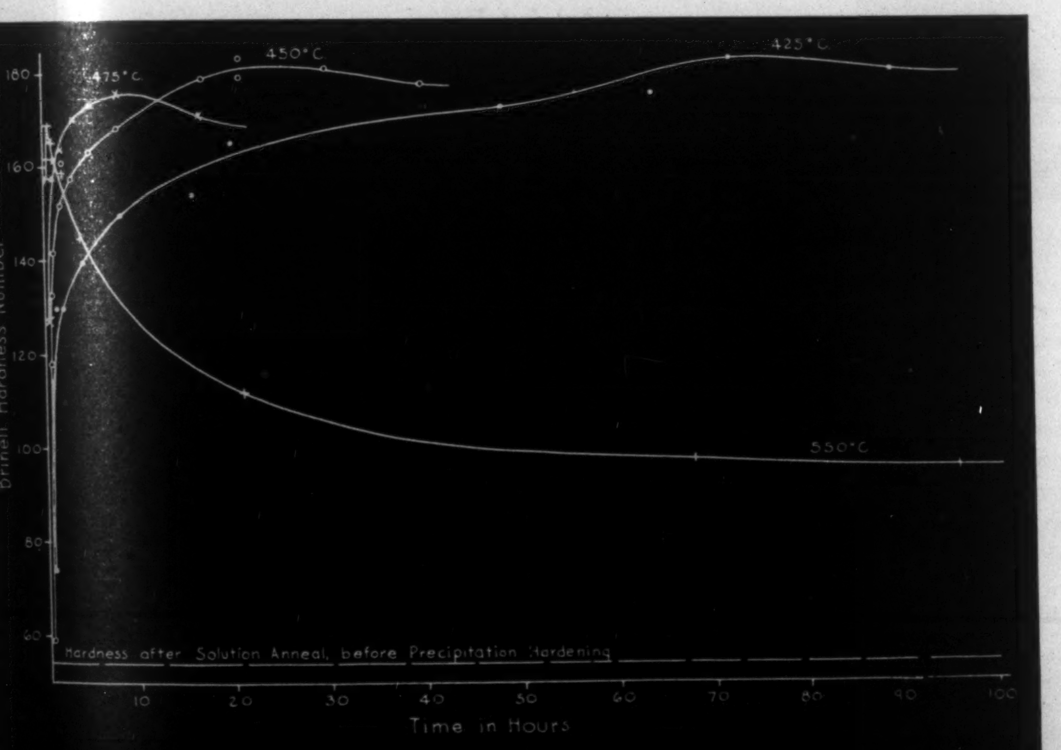
Age-hardening by Heat Treatment

Curves showing the effect of time and temperature of age-hardening treatment on the hardness of these alloys are shown in Figs. 7-11. There was no perceptible hardness gain at room temperature with any of the alloys over a period of many months.

The following observations may be made from the curves:

1. Hardening takes place with comparative rapidity at first then more slowly as the forces urging atomic rearrangement become partially satisfied.
2. After reaching a maximum value, hardness decreases somewhat according to the temperature. This overaging is slower when hardening at the lower precipitation temperatures but becomes increasingly rapid as the temperature of precipitation is raised.
3. Increasing the temperature of the precipitation treatment greatly shortens the time for maximum hardness to be reached.
4. The maximum hardness value reached decreases with increasing temperature of precipitation. This is undoubtedly due to the greater solubility of the precipitant at these higher temperatures leaving a lesser volume of precipitating solute for hardening.

Fig. 7. Effect of Aging Time on Hardness; Series C Alloy 0-100 Hour Range.



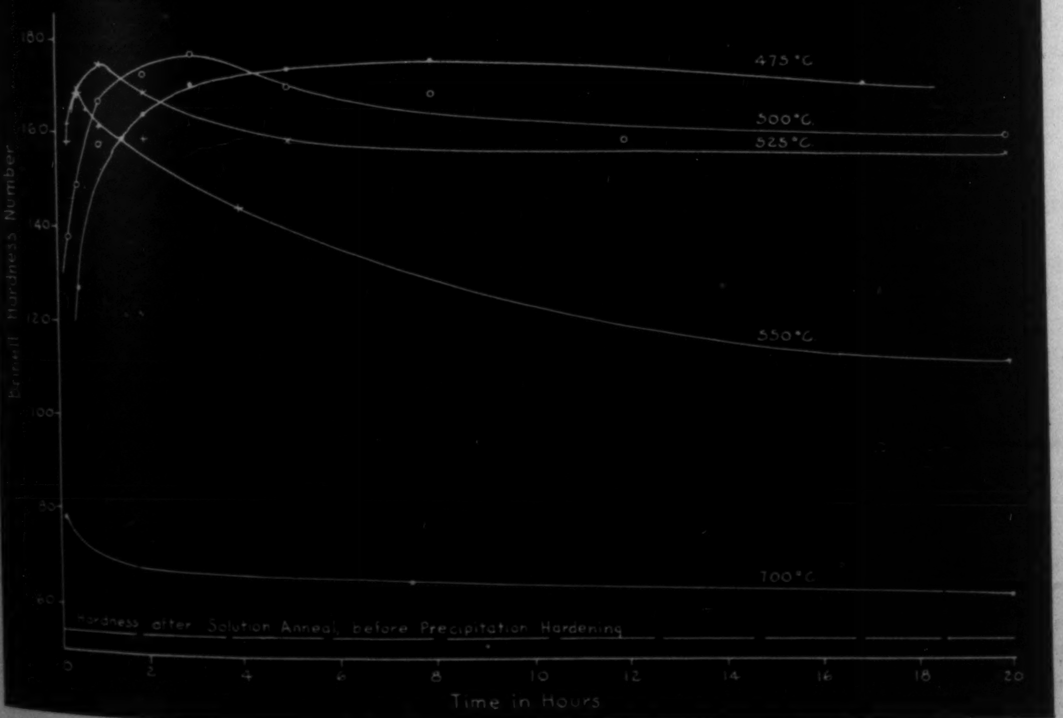


Fig. 8. Effect of Aging Time on Hardness; Series C Alloy 0-20 Hour Range.

Table 5. Effect of Overaging and Reprecipitation.

Brinell After Solution Anneal	Aging Treatment hrs.	Aging Treatment °C.	Aging Treatment Brinell	Retreatment 2 hrs. at 500° C. Brinell
		Series C Alloy		
56	6	800	52	168*
"	0.1	700	80	138
"	1	"	70	106
"	7.5	"	67	73
"	15	"	66	76
"	24	"	61.5	90
		Series A Alloy		
68	—	—	—	209
65	0.1	700	160	195
68	1	"	147	185
65	7.5	"	130	165
65	24	"	119	162

* Slightly less than normal hardness due to long solution annealing treatment.

Overaging

The trend of all the curves indicates a relatively sharp decrease in hardness after the maximum has been attained, followed by a gradual softening to a level of apparent stability. This hardness level is high when aging at comparatively low temperatures (within the limits of the tests made) but drops lower with increasing temperature until at 700° with Series C alloy it is very little higher than the hardness following the solution anneal. At these higher temperatures aging proceeds so rapidly that the maximum hardness may be passed before the specimen has well attained the furnace temperature. The curves at 700° show only part of the overaged portion for this reason.

Because of the time involved, extended overaging tests were made only at higher temperatures where the definite trend was unmistakable in a reasonably short time. These are shown especially by the curves at 550° and

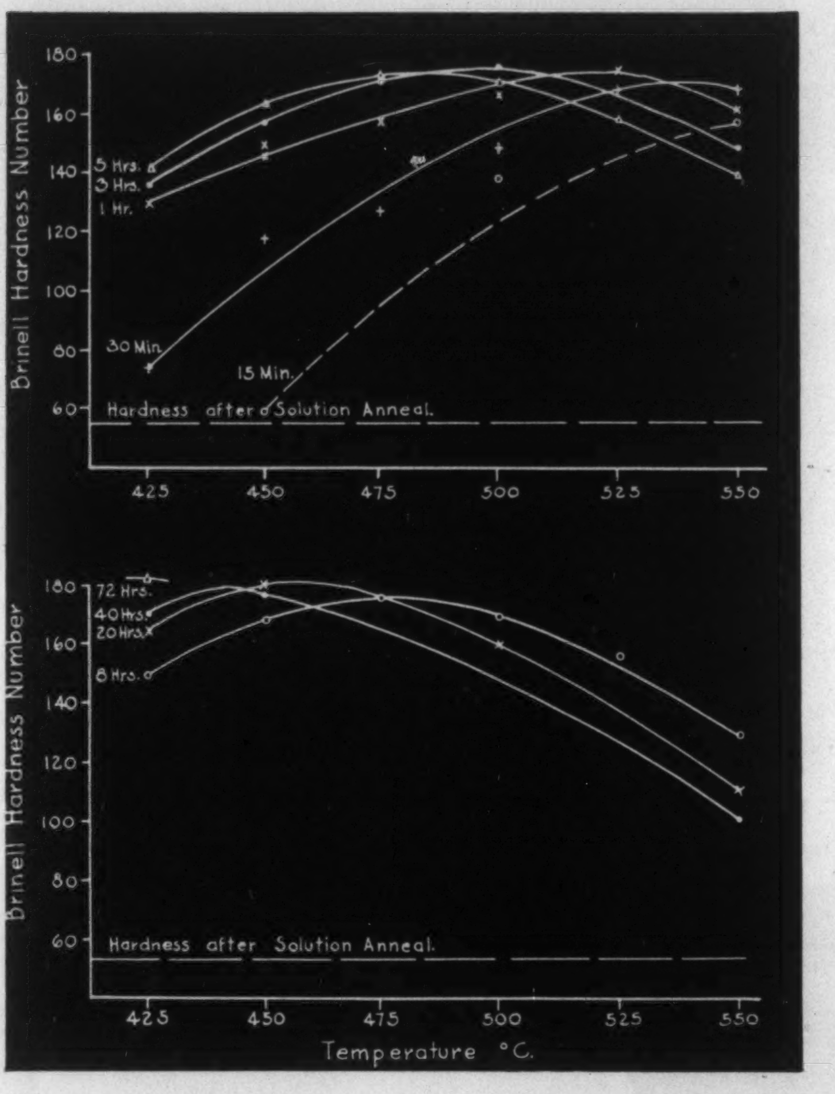


Fig. 9. Effect of Aging Temperature on Hardness; Series C Alloy.

700° in Figs. 8 and 11. Overaging or agglomeration tests made with Series B alloy shows the same trend as with Series C alloy.

That decrease in hardness after passing the maximum is really overaging and not due entirely to resolution of precipitated nickel silicide or other hardening agent is demonstrated by attempts to reharden or reprecipitate material which has been overaged. Table 5 shows the results of overaging at 700° and of attempted reprecipitation or a secondary aging treatment of 2 hours at 500°. All samples were given an initial solution annealing treatment under comparable conditions.

When quite completely overaged, as for 7.5 to 15 hours at 700°, the Series C alloy is only 10 to 11 points Brinell harder than in the solution annealed state, and an additional precipitation treatment under conditions which would normally give nearly maximum hardness has but a slight hardening effect. Undoubtedly some resolution does take place with long continued heating at this temperature as shown by the gradual softening at 700° and increased response to hardening at 500°.

Since the Series A alloy requires a much higher temperature or longer time for aging than the C alloy, the results as given in the second part of Table 5 roughly correspond with the C alloy range of 0.1 to 1 hour. By overaging at a higher temperature as 775° or 800° C., the same drastic softening would undoubtedly be secured as with the C alloy.

Apparently a repeated precipitation treatment following an overaged stage at high temperatures is much more effective in producing additional hardness when the material has been but slightly overaged than when overaged for a long time. This is indicated by the results of aging Series C alloy for 0.1 and 1.0 hour at 700°.

These results are not readily explained by the simple theory of precipitation hardening since on overaging one would expect any hardening solute to be completely precipitated and more or less agglomerated. In such condition reheating at a lower temperature would have no appreciable hardening effect.

This may be considered evidence of a change which takes place between 500° and 700°, possibly an allotropic transformation or change in solubility to form a new constituent as suggested by Wilson, Silliman and Little[6] from irregularities in electrical conductivity between these temperatures. Such a change is apparently complete after several hours in the case of the Series C alloy, as evidenced by inability to substantially reharden the material by reheating at a lower temperature. Before such a change is complete, however, the normal age-hardening forces which exist at 500° can produce marked additional hardness.

Untabulated results on the effect of varying the time of rehardening treatment indicate that the hardness change follows the same trend as in the curves for primary aging (Figs. 7-11).

Effect of Repeated Cycle of Age-hardening and Reannealing

Samples of Series C alloy which had been given a standard solution annealing treatment were variously heat aged, cold worked or overaged at a high temperature, then all given the same solution anneal and again aged. Identical conditions were maintained in annealing to give the directly comparable results of Table 6.

Table 6

1st Cycle Precipitation Treatment			2nd Cycle Solution Anneal	2nd Cycle Precipitation Anneal
			1 hr. at 800° C.	3 hrs. at 500° C.
hrs.	°C.	Brinell	Brinell	Brinell
Cold drawn		103	54	174
0.75	450	133	53	174
0.5	500	149	53.5	174
2.0	500	175	54.5	174
***		141	57	...

*** Overaged at 600° to Brinell 125 and reaged 30 minutes at 520° to Brinell 141.

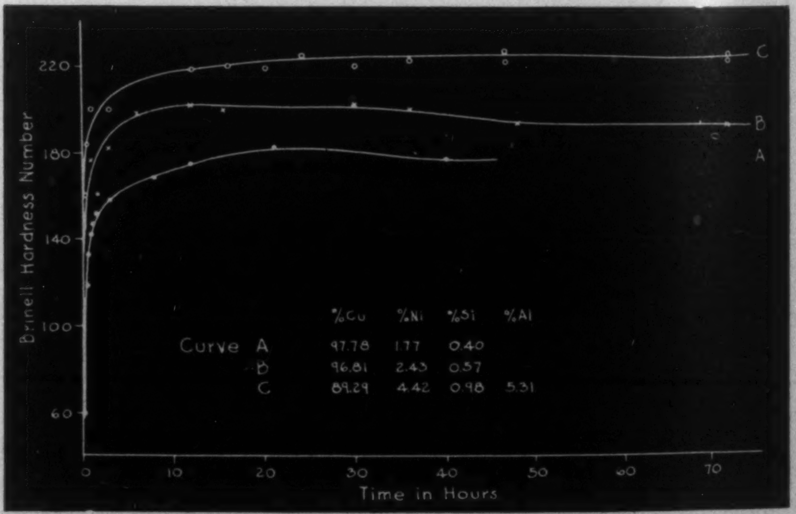


Fig. 10. Comparative Effect of Alloy Composition on Hardness During the Aging Treatment at 450°C.

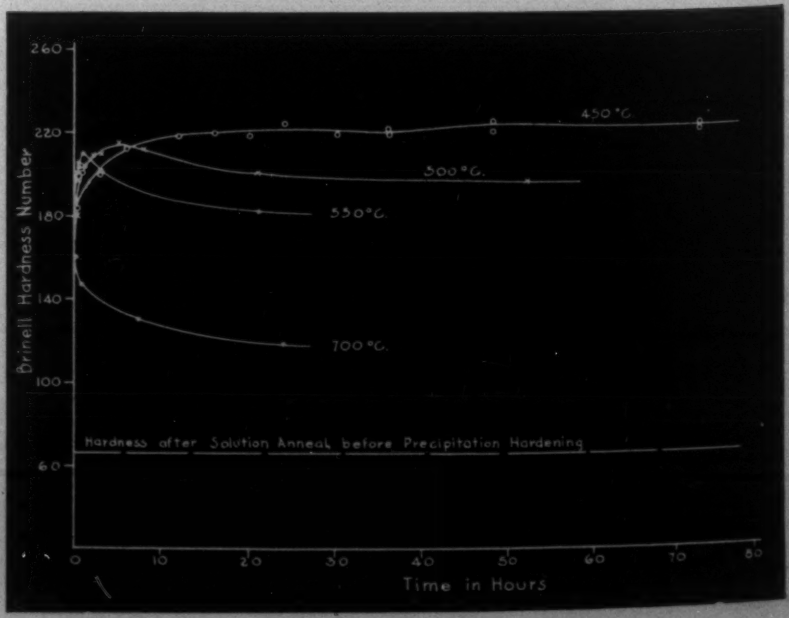


Fig. 11. Effect of Aging Time on Hardness; Series A Alloy.

A slight indication was obtained of greater ease of resolution by incompletely heat aged material than by fully aged or worked material but insufficient to show a marked difference. The sample overaged at 600°, however, definitely gave less complete softening after the relatively drastic solution annealing treatment. This indicates a slower rate of resolution after overaging at a relatively high temperature.

The final aging treatment at 500° gave the same hardness for all the samples tested. Previous history apparently has no effect as long as the samples are of similar composition and are completely solution annealed.

Slow Cooling from Temperature of Solution Anneal

By very slow cooling from the solution annealing temperature one would expect gradual precipitation and agglomeration of excess solute as the solubility of nickel silicide is exceeded. Various factors interfere to complicate the results secured from such tests, however. In Table 7 are given results of a few such furnace cooled tests.

Table 7. Furnace Annealing Treatment

Alloy	Temp. °C.	Brinell*	Cooling Range	Final Brinell
C	900	53	**	131
B	900	53	**	128
B	800	56	***	85
A	900	68	**	135
A	900	68	****	109

* Hardness if quenched, from comparison with solution annealing tests.

** Cooled in furnace. 900°–730°, 2½ hrs.
730°, 2 hrs.
730°–140°, 13½ hrs.

*** Cooled in furnace. 700°, 8 hrs.
700°–100°, 10½ hrs.

**** Cooled in furnace. 800°, 1 hr.
700°, 8 hrs.
700°–100°, 10½ hrs.

The treatment for Series C alloy consisted essentially of cooling from 730° since no action would take place above that temperature. The resulting hardness compares with an aging treatment of less than an hour at 700° followed by reaging at 500° as given in Table 5. Comparatively, less hardness is secured with Series B and A alloys under the same heat treatment because of the softening effect of continued heating at 730° and above. A long treatment of these alloys at 700° is still more effective in producing a low final hardness. Slow cooling from a high temperature is apparently very similar to overaging at a high temperature followed by reaging at a lower temperature as discussed in connection with Table 5.

(Continued in December issue)

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Science Applied to Industry

A general idea of the work of Battelle Memorial Institute, Columbus, Ohio, in its relation to industry may be obtained from its new booklet which is profusely illustrated with views of its numerous laboratories and up-to-date equipment.

This Institute was founded and endowed by Gordon Battelle and his mother, Annie Norton Battelle to promote and further research and education in metallurgy and fuels and allied fields and, in order to increase the scope of its work and usefulness, has adopted a policy of conducting research and development for industry.

Herty Now at Bethlehem

Dr. Charles H. Herty, Jr. has been appointed a Research Engineer in the Development and Research Department of Bethlehem Steel Company. Dr. Herty was formerly Director of Research of the Metallurgical Advisory Board of the Carnegie Institute of Technology. Dr. Herty was graduated from the University of North Carolina in 1918 and from Massachusetts Institute of Technology in 1921. His doctorate degree is Doctor of Science. His duties are effective immediately.

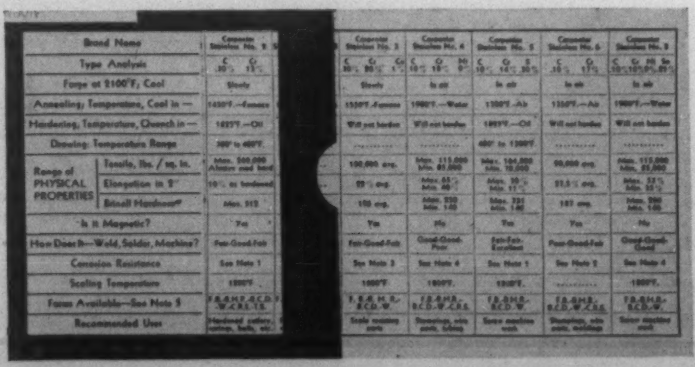
Research on Enameling Expanded at Mellon Institute

The Hommel Company authorized Mellon Institute to add another specialist to the Hommel Fellowship and it has just been announced by Dr. Edward R. Weidlein, director of the institution, that William J. Baldwin has been appointed to this post. Mr. Baldwin is a ceramic chemist who was educated professionally at the University of Buffalo (B.S., 1926) and was in the employ of the American Radiator Company at Buffalo from 1926 until he joined the Institute on October 1. During his eight-year connection with the American Radiator Company, Mr. Baldwin became acquainted with the problems of vitreous enamel. He gained experience in the analysis of raw materials and the utilization of various chemicals in frit making. In addition to laboratory research work on vitreous enamels he has had practical experience in the wet-process enameling field, including both steel and cast-iron enamels, and with the American Radiator Company he served as foreman of the mill room and the smelting department.

Gilby Wire Organizes French Company

Mr. Wilbur B. Driver, President of Gilby Wire Company, Newark, New Jersey, announced upon his return from Europe the establishment of a new French company to take over the European business of the Newark company. The new company, known as Gilby Wire Société Anonyme with the main office at 11 bis Rue d'Aguesseau, Paris and plant at 76 Boulevard Richard Wallace, Puteau, France commenced business on September 1, 1934. Mr. Gabriel Fodor formerly European Manager of the Gilby Wire Company, Newark, will direct the affairs of the new company.

Carpenter Stainless Steel Slide Chart


Brand Name
Type Analysis
Forge at 2100°F; Cool
Annealing; Temperature, Cool in —
Hardening, Temperature, Quench in —
Drawing: Temperature Range
Range of PHYSICAL PROPERTIES
Tensile, lbs. / sq. in.
Elongation in 2"
Brinell Hardness
Is it Magnetic?
How Does It—Weld, Solder, Machine?
Corrosion Resistance
Scaling Temperature
Forms Available—See Note 5
Recommended Uses

The Carpenter Steel Co., Reading, Pa., has prepared a stainless steel slide chart. One side of the chart tells about properties of *any* stainless steel, while on the other side (shown above) it summarizes the properties of all Carpenter stainless steels.

Apparatus and Method for Metallographic Work at Low Temperatures

by O. A. Knight †

THE STUDY of metallographic changes taking place at very low temperatures has recently aroused considerable interest. As a result of numerous inquiries it seems advisable to describe in some detail methods used in one such study in the hope that it may bring suggestions as to improvement in technique and stimulate similar work on other types of material.

A paper* presented at the meeting of the American Institute of Mining and Metallurgical Engineers in February 1934 described methods used in a preliminary study of austenite-martensite transformations at the temperatures of dry ice and of liquid air.

The present paper goes more into detail regarding the apparatus used and its manipulation and describes further work along this line.

Fig. 1 shows a section through the equipment as finally used. In the assembled apparatus, the specimen A, rested on the threaded cap B, open at the lower end. Into the upper end of this cap was screwed the threaded pipe C, until it rested against the specimen. Between the threaded pipe and the specimen, and between the specimen and the threaded cap, rubber gaskets I were inserted to prevent leakage. Tripod E, with adjustable feet for levelling, was slipped over the upper end of the threaded pipe and prevented from coming off by the threaded ring D. This assemblage could be placed on the microscope stage for examination, leaving an open space between the threaded cap and the objective J, thus making it possible to connect the cap and the objective with a thin rubber hose K, into one side of which was inserted the glass bulb G, containing phosphorus pentoxide as a desiccating agent. For examination, a brine-quenched, polished specimen was inserted in the apparatus, fresh P_2O_5 was put into the glass bulb, and the assembly was placed on the stage of a large metallograph. The surface of the specimen was leveled and focused, after which several hours were permitted to lapse in order to permit the atmosphere enclosed between the specimen and objective to become thoroughly dry. If this precaution were neglected, moisture would condense and freeze on the specimen and obscure the vision of the metal surface. When temperature measurements were desired, a very small (28-gage wire), carefully calibrated, copper-constantan thermocouple was employed, with its junction secured to the polished surface of the specimen by a tiny strip of adhesive tape. The image of the specimen was projected onto the ground glass of the metallograph or onto a screen immediately back of the open bellows.

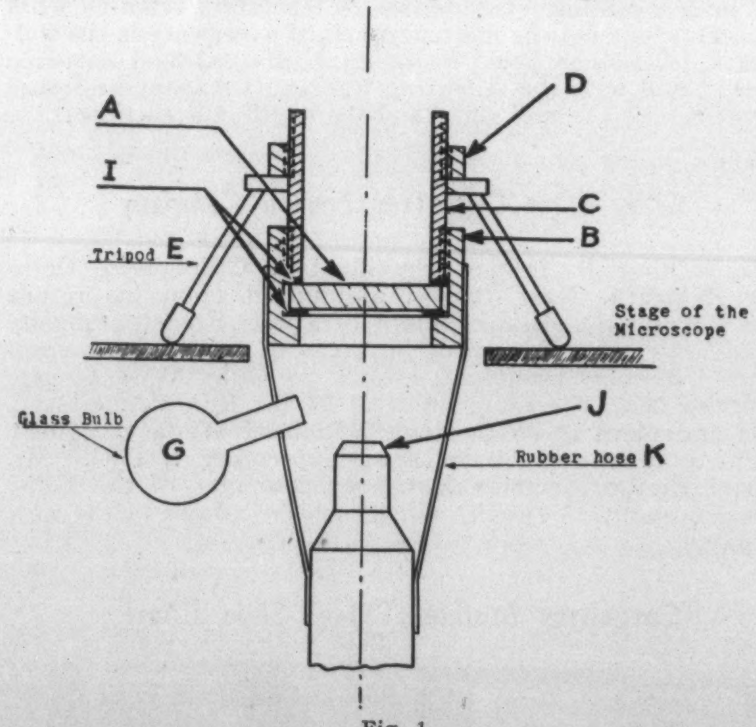


Fig. 1

THERE is no way so effective in giving one an understanding of a metallurgical phenomenon as to see it actually happening. The change from soft austenite to hard martensite, the basis of all the heat treatment of steel that involves quenching and tempering, can now be watched under the microscope, and it will probably be displayed to every metallurgical student as time goes on.

Details by which this can be readily accomplished are given in this article by Professor Knight so that other students besides those of Penn State may be able to watch this interesting transformation.

An electric fan was so placed as to prevent the fumes from the liquid air from interfering with the light from the arc. When all was ready, the cooling was done by either solid carbon dioxide and ether or by liquid air. When the former was employed, ether was poured into the container (the bottom of which was the specimen and the sides the threaded pipe) to a depth of about ½ in. and into this, chips of dry ice were inserted. With a little practice, the rate of cooling could be fairly well controlled. The cooling efficiency of the apparatus may be estimated by noting that the thermocouple on the polished surface registered —76°C when dry ice and ether were used, and well below —150° when liquid air was employed. The rate of cooling with liquid air was also susceptible to a certain measure of control by the rate at which liquid air was poured in.

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† Associate Professor of Metallurgy, The Pennsylvania State College, State College, Pennsylvania.

* Observing Formation of Martensite in Certain Alloy Steels at Low Temperatures, by O. A. Knight and Helmut Müller-Stock. Technical Publication No. 537, American Institute of Mining and Metallurgical Engineers, *Metals Technology,* June 1934, 7 pages.

If greater efficiency were desired the whole apparatus may be packed with wool or other convenient heat insulation. In one instance cotton was used with worth-while results. By using a relatively thin specimen (1/4" or less) low temperatures can be easily obtained on the surface being examined. The specimens employed are usually about 1/4" thick. The apparatus and procedure seems to be quite simple and it is as long as each detail is given proper attention. These details will now be given.

The rubber gaskets I, inserted both between the threaded pipe and the specimen and between the specimen and the threaded cap gave considerable trouble, at times, by failing to prevent leakage. The result was that liquid would leak through, flow over the face of the specimen and spoil the results by obscuring the surface under examination. Unlike contraction of the different parts, due to differences in coefficient of expansion, makes leakage somewhat difficult to guard against.

If the rubber gaskets are coated with paraffin before and after assembling and if the specimen has been machined so its top and bottom surfaces (where the gaskets contact it), are parallel, no leakage should occur. Of course, when ether and "dry ice" are employed as the cooling means, paraffin is out of the question entirely, since it dissolves so readily in ether. Under these conditions leakage can be overcome by using rather heavy gaskets of rubber cut from an automobile inner tube or similar material and by screwing the threaded cap and the threaded pipe firmly but not too tightly, against the rubber gaskets. If the upper and lower faces of the specimen are parallel and smooth little difficulty will be experienced. However, it is wise to test for leaks after the specimen has been assembled in the apparatus (but before attaching the rubber connection between the objective and the threaded cap) by pouring in some ether and observing it for 10 or 15 minutes. Any necessary adjustments can then be conveniently made.

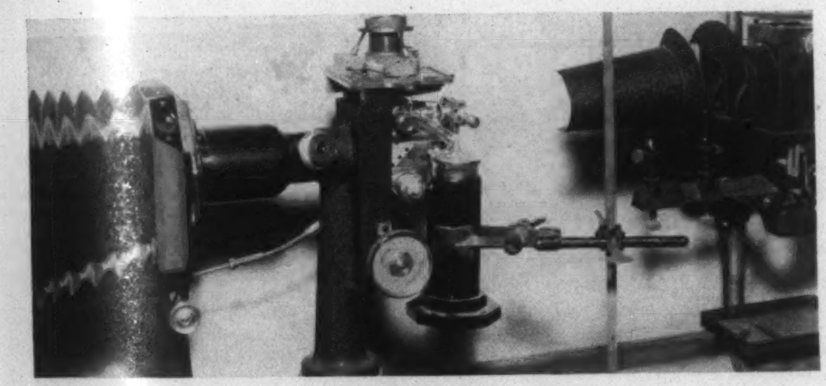


Fig. 2

Additional difficulties are encountered when one is working with small specimens that require mounting in order to fit the cold treating apparatus. There are many mounting materials and methods but only a few have been tried for this particular purpose. The behavior of some in liquid air, of course, renders them undesirable. Wood's metal has proven fairly satisfactory for this purpose although some trouble was experienced by poor contact between the specimen and the mounting material with the result that, liquid (either liquid air or ether) leaked through to the polished face of the specimen by way of the crack between specimen and mount. Sometimes this leak is mistaken for a leaky gasket and if it is a "slow leak" it may be difficult to detect. To overcome this is simple when using liquid air as a coolant, for an application of paraffin with a small brush along the contact line will do the trick. When dry ice and ether are to be used a small pointed soldering iron can be used to seal the contact between specimen and mount after the polishing and etching has been done, that is, just prior to assembling the specimen in the apparatus. If this is done earlier the seal may be broken during the polishing and etching operations. When applying paraffin to this junction, care should be taken to avoid coating the back of the specimen except at the junction, since such a coating, if spread over the entire back of the specimen would have some effect on the cooling velocity of the specimen.

In some work, especially when in a hurry to desiccate the air, the glass bulb G, containing P_2O_5 was replaced by a small tube sealed at its outer end and this sealed end inserted in a Dewar tube, cooled by either "dry ice" and ether or by liquid air. The other end of the glass tube is left open and extends through the rubber partition into the space between the specimen and objective. By cooling the portion of the glass tube in the Dewar tube for some 5 or 10 minutes before cooling the specimen the moisture in the space between specimen and objective will be frozen out and will, therefore, cause no trouble by freezing onto the specimen. The Dewar tube may be set up near the microscope stage and the glass tubing bent to fit. The tubing leading to the Dewar should be of rather large bore in order to minimize the time required for removing the moisture.

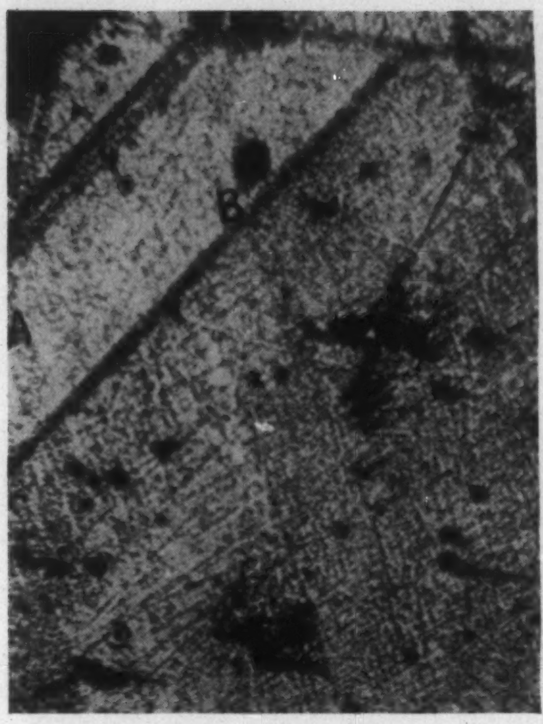
Fig. 2 shows the cold treating apparatus in place on a metallurgical microscope. The Dewar tube, with its glass tube inserted is shown clamped to a ring-stand.

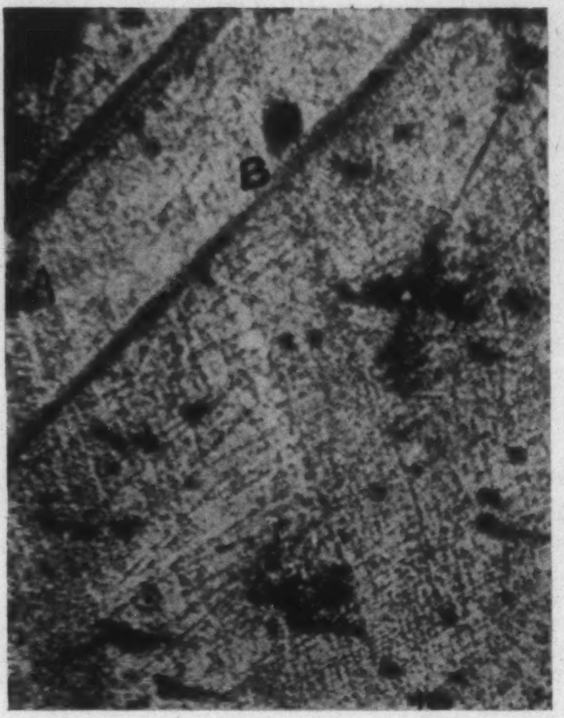
No trouble has yet been experienced with the objectives although this was predicted by all of the optical companies consulted. It was thought that the lenses would be either distorted or crushed by the contraction of the metal on the glass, but so far this has not happened. Only 14 mm. objectives have been employed, however, which are relatively at a considerable distance from the specimen. Just what would occur if a 4 mm. objective were used can only be ascertained by trial. It is believed that a suitable covering, or shield, could be put on such an objective so that it would function satisfactorily.

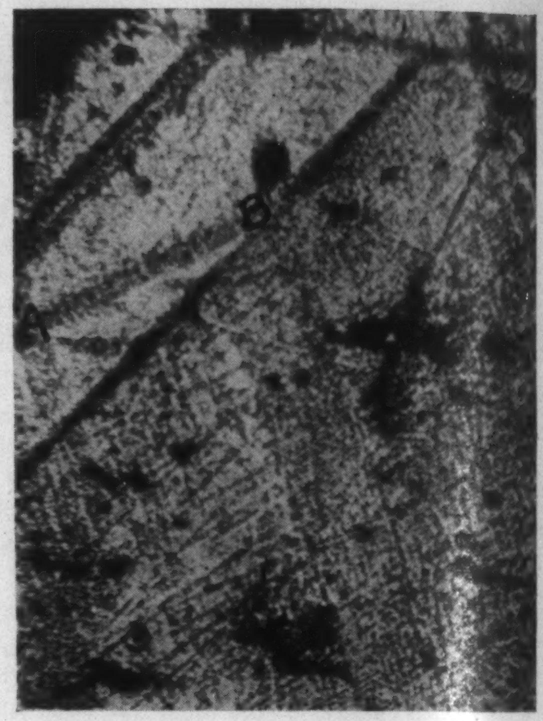
The most satisfactory way of handling the liquid air is to use a rather large Dewar tube and stopper it with a two-hole stopper with glass tubing arranged in wash-bottle fashion. The liquid can then be squirted into the cold treating apparatus and into the desiccating Dewar as required. An ordinary thermos bottle works quite well for transporting liquid air. The wash-bottle stopper is essential to avoid pouring over the lip because pouring in this manner often results in breakage.

The fumes from liquid air sometimes intercept the light from the arc and thereby interfere with the illumination of the specimen unless steps are taken to prevent it. An electric fan placed on the floor and running at slow speed keeps the fumes blown away.

Moving pictures of the formation of martensite were obtained through the courtesy of the Eastman Kodak Company, by attaching a Cine-Kodak Special moving picture camera to the projection eye-piece of the microscope and by firmly anchoring the camera to the microscope bench in order that vibration would be minimized. Enlargements from the moving picture film are shown here. The specimen used was prepared by Mr. S. L. Weaver, a senior student in metallurgy at Pennsylvania State College, the motion pictures were taken by Mr. R. J. Dwyer of the Eastman Kodak Company.







A minute or two elapsed between first set above and the second set, below

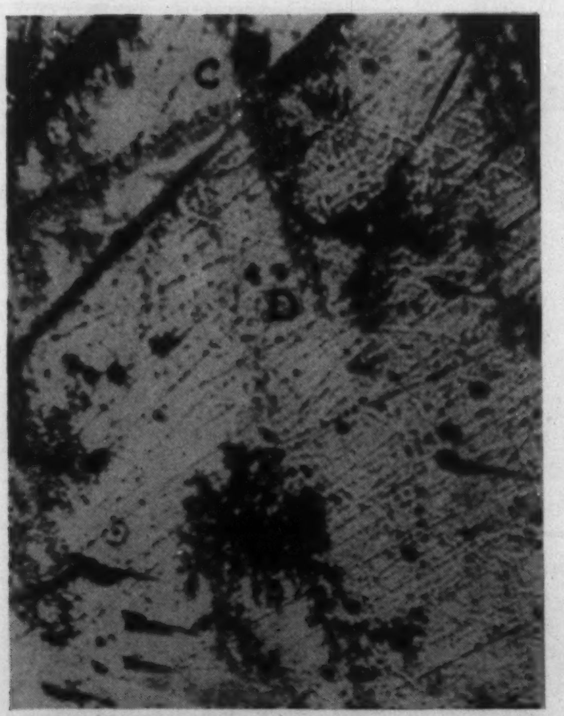
FIRST SET OF THREE, ABOVE

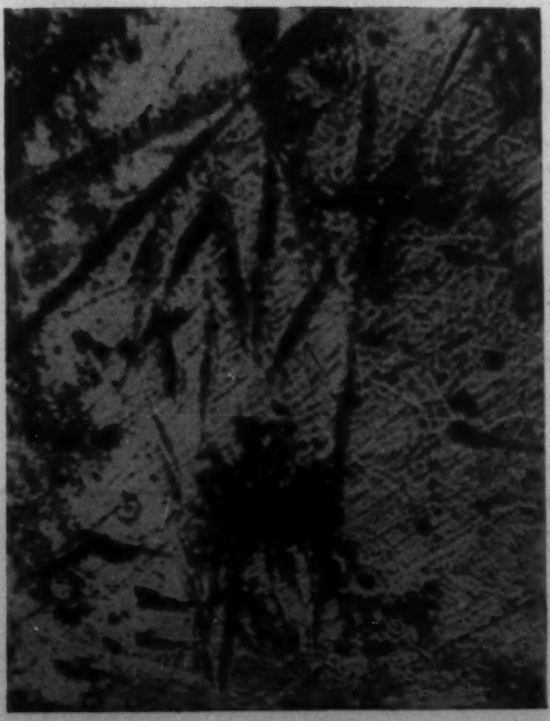
Original austenite. Set 1, Neg 1, left.

Start of 1st needle of martensite, showing very faintly between A and B. 1/16 sec. after Neg. 1 of this set. Set 1, Neg. 2, center.

Completed needle between A and B. 1/16 sec. after Neg. 2 of this set. Set 1, Neg. 3, right.

A minute or two elapsed between second set at left and the third set, below





SECOND SET OF 2, AT LEFT

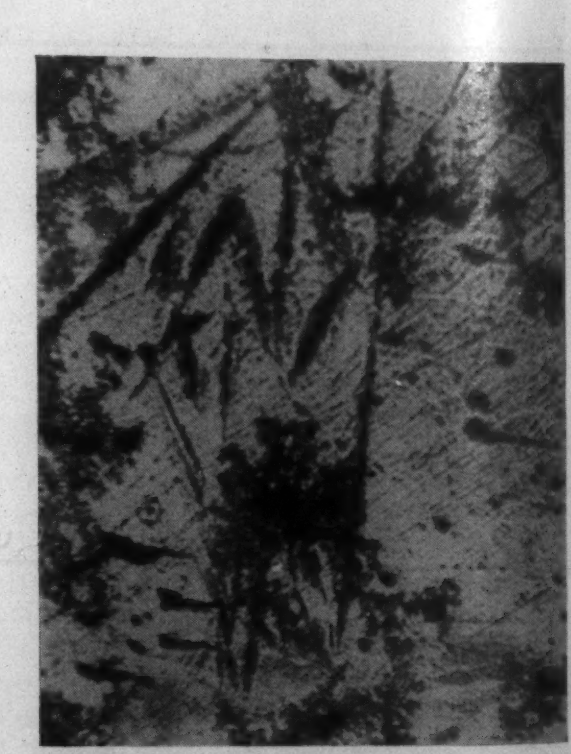
A second needle, not well defined, between C and D. Set 2, Neg. 1, upper.

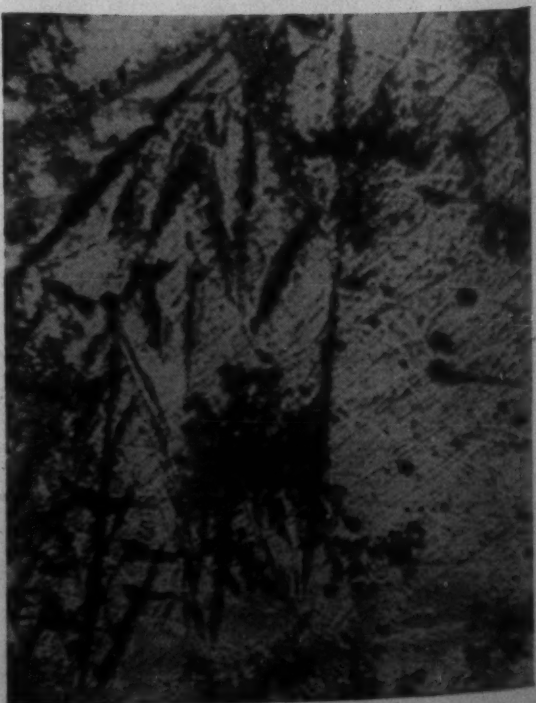
Two new groups of needles. Formed 1/16 sec. after Neg. 1 of this set. Set 2, Neg. 2, lower.

THIRD SET OF 2, AT RIGHT

Structure about the same as shown in Set 2, Neg. 2. Set 3, Neg. 1, upper.

1/16 sec. after Set 3, Neg. 1 the "pine tree" needles near E appeared. Set 3, Neg. 2, lower.





All magnifications
were 160 × at the film.
(16 mm. film)

LETTERS TO EDITOR

Metallurgical Research in Germany

Editor, METALS & ALLOYS:

I will gladly follow your suggestion to comment on metallurgical research in Germany as it appeared to me on my trip this summer.

I visited the Research Institutes of Krupp Vereinigte Stahlwerke and Deutsche Edelstahlwerke. I was also at the Kaiser Wilhelm Institut fuer Eisenforschung in Duesseldorf, at the Eisenhuetten Institutes in Freiberg, Aachen and Berlin. All institutes have excellent and the most recent equipment in almost every line of research, the latest types of metallographic microscopes, testing apparatus, X-ray equipment, melting and heat treating tools, experimental rolling mills, etc. I was simply amazed. Besides this standard equipment, I found many specially constructed pieces of apparatus of most ingenious design, mentioning as an example only Esser's new types of calorimeters and dilatometers. As you probably know, there is a new Kaiser Wilhelm Institut fuer Eisenforschung just being built, although I found the old one still very up to date. Koester has left the Edelstahlwerke to become director of the new Kaiser Wilhelm Institut fuer Metallforschung (located in Stuttgart) and Scheil from the Vereinigte Stahlwerke has joined him.

The type of research work done is of the highest order. I have spoken in detail with many a research worker at the various institutes and I was greatly impressed by their ability and attitude.

Besides the work in the institutes I found a great deal of research going on in the plants or in connection with the plants. I mention only the fundamental investigations on large forgings by Director Korschan of Krupp and some work on internal stresses done at the Vereinigte Stahlwerke.

The German Chemical Trust (I. G. Farben) has also greatly increased the Metallurgical Staff to carry on development work in "Ersatz" metals. The electrical industry and the aluminum industry are working in the same direction. It is one concentrated and determined effort to get Germany successfully through the present period. I feel sure that the future will bear the fruits of their efforts in the form of new processes, new materials and many new patents. Maybe Germany will not be the final loser of the boycott directed against her.

These research activities are approved directly and indirectly by the new government. The latter is boosting for instance the automobile industry by abolishing all taxes on new cars and by building a system of excellent highways. The automobile industry is a very good customer of the steel and metal industry.

The government also tries to make Germany air minded. I visited the Junkers Werke in Dessau and saw their plants being doubled in size. This puts up new problems to the special steel maker and the light metal industry. Radio has been greatly favored by Dr. Goebbels and there are many metallurgical problems in the radio industry. Railway transportation, housing, telephone and television communications are improved or newly created. I could go on for some time naming activities, all contributing to an enormous stimulation of metallurgical research activities.

Oct. 8, 1934. — F. R. HENSEL
Indianapolis, Ind. — P. R. Mallory & Co., Inc.

Heredity in Cast Iron

Editor, METALS & ALLOYS:

May I make a correction to the correlated abstract on "Heredity in Cast Iron," page 184 of the September issue and also contribute some information that is pertinent to the study of the quality of cast iron?

During the discussion of oxygen in cast iron you refer to the paper of Dr. Reeve on the fractional oxygen determinations and state that no results of this method have been reported for cast iron. Actually Dr. Reeve did report on this question in a foot note to the effect that despite the high silicon content of cast iron, some samples are badly "oxidized." Poor cast iron analyzed as high as .04% oxygen as FeO and MnO (of which much was FeO) while the oxygen as SiO_2 averaged only .007%. The results on samples of good iron ran much lower, or 0.004% oxygen as MnO and 0.001% as SiO_2. The total oxygen contents of the two types of iron ran about 0.06 and 0.006% respectively. The results indicate the possibility of the existence of badly oxidized metal in which the normal course of deoxidation has been stopped at a point which is far from equilibrium. It also follows that during the extraction of the FeO fraction, reduction by metallic silicon at the low temperature is negligible.

The fractional oxygen determinations were fully corroborated by microscopic examinations with ordinary illumination and by reflected polarized light. In particular the poor irons showed an appreciable amount of iron oxide in spite of the high carbon and silicon contents of the metal. This study of cast iron gave such promising results that we would expect a more extended study of oxygen in cast iron to be very fruitful.

Sept. 27, 1934, — SAMUEL L. HOYT
Milwaukee, Wis. — A. O. Smith, Corp.

Steel Casting Progress

Editor, METALS & ALLOYS:

Mr. Rawdon's review of the ferrous metallurgical developments that have occurred during the past five years is extremely interesting. The summary indicates much but not all of the progress made in the period mentioned. As the author has suggested, two men attempting any such review would not be apt to agree on the appropriate listing of all of the accomplishments.

It would appear that Mr. Rawdon may not have had his attention directed to the progress made in steel casting manufacture during the last five years. The circumstances of industrial demand naturally have steered much (but by no means all) of the investigational work and commercial production incidental to steel founding into the field of special metals, with the result that the manufacture of low alloy and high alloy cast steels is now on a basis commanding much respect.

At the present time there are probably 65 grades of alloy steel, so called, being produced in the foundry industry. It is true that some high alloy grades are of such compositions as to prompt qualified persons like Mr. Rawdon to declare that these metals cannot correctly be designated as steels. However, there are many high alloy grades of ferrous metals being put into castings which all informed persons would class as steels. In any case, it is partially indicative of progress made by the steel casting industry that a considerable number of its foundrymen have been devoting marked attention successfully to grades of cast steel carrying large percentages of chromium, nickel, etc.

The fact that progress has been made in the steel casting industry during the last five years was demonstrated in 1933 by the Testing Society's tentative adoption of specifications calling for eight grades of alloy steel castings, to supplement requirements previously adopted by the A. S. T. M. for but one cast alloy steel grade (Austenitic manganese); also by the fact that for some time a committee of the A. S. T. M. has been tackling the problem of developing purchasing requirements for several other grades of metal produced in the steel foundry, intended primarily for resisting corrosion. Progress in the same general direction has been further manifested through activity by another committee of the Testing Society, which this year developed tentative specifications for eight grades of alloy steel used in the manufacture of products for service temperatures as high as 1100° F. (mainly in the oil and power industries).

Necessarily, before equitable purchasing requirements can be agreed on by any large group of technically qualified representatives of producers and consumers, there must be much development work in making and considerable experience in using the affected product. Therefore, the tentative agreements reached in 1933 and 1934 by the American Society for Testing Materials regarding the properties that should be developed in each of sixteen grades of alloy cast steel never previously covered by any A. S. T. M. specifications are significant manifestations of substantial progress commercially attained recently in the production of special grades of steel for castings. Incidentally, new tentative specifications adopted by the Testing Society in 1933 show progress in making carbon steel castings.

Mr. Rawdon's review contained one comment regarding welding which is of special interest to those making cast and other products of steel. I refer to this statement:

"The proud boast of the welding expert that there is no steel or iron which cannot be successfully welded is literally true."

The term *"successfully"* means different things to different people. Probably no one should contradict Mr. Rawdon's terse statement, because of the various interpretations that may be made of the word above in italics. But a few comments may be in order, both to prevent some misunderstandings by consumers, and to stimulate, for the best interests of all concerned, the welding engineers to whom many industries undoubtedly owe a great deal. A union that would be regarded as successful for one grade of steel, and for one joint to be subjected to a certain variety of stresses of given magnitudes, might not be at all suitable for combinations of stresses applied to other parts of the same structure. The particular job which has to be done by the welded joint regulates the evaluation of the fusing operation. There are a number of established grades of cast steel which the foundryman apparently cannot now but would like to weld commercially so as to develop in the deposited metal (and in the adjacent zone) properties substantially like those characterizing the parent cast material. It is not surprising, despite great constructive activity by welding engineers, that this situation prevails, due partially to the very large number of grades of steel being produced.

The progressive steel foundryman wants to see further progress made in these directions. He is influenced not only by the natural wish to salvage defective castings, but to provide greater opportunities for the use of cast parts in composite construction that involves their use and that of wrought shapes, joined together by fusion. Of course, the comparable properties that are desired include not merely the resistance to mechanical stresses, but relatively destructive factors such as corrosion, high temperature, etc.

To prevent being misunderstood, may I say finally (as I have said before in print) that when this welding problem is viewed broadly, it seems clear that mutual interests should prompt hearty cooperation between welding engineers and steel foundrymen. In a somewhat peculiar sense, their arts are complementary.

Chicago, Ill.,
Oct. 9, 1934.

R. A. BULL

Stainless Steels

Editor, METALS & ALLOYS:

METALS & ALLOYS for October is most interesting and valuable. An occasional review of progress in metallurgical developments is indispensable to those of us whose work is largely confined to special phases of metallurgy. The writer, speaking for himself and colleagues, wishes to extend his heartiest congratulations to the editor.

Noteworthy and significant is the prominence given to discussion of Stainless Steels by Mr. Rawdon in his excellent contribution to the October issue, entitled "Ferrous Metallurgical Developments." To condense such a new and intricate subject into a few paragraphs, without sacrificing a great part of its essential meaning, is a worthwhile accomplishment, and of course the author could not be expected to take cognizance in passing of many of the complexities of his subject.

One knotty metallurgical problem of major importance, about which much has been said and written in the last three years, is the phenomenon of carbide precipitation in the 18% chromium 8% nickel group of Stainless Steels; its significance, and the avoidance of its worst consequences. Mr. Rawdon has quite properly included mention of this problem in his article, but unfortunately he seems to imply that it is solved, a thing of the past, with all medals duly awarded. It is considered that such a conclusion is somewhat premature, and that it conveys, no doubt unintentionally, implications that are damaging to the industry. Although the writer is reluctant to take issue with Mr. Rawdon's views, it is undoubtedly true that metallurgists of the industry are not united in their endorsement of them. Indeed there are in the ranks of both producers and consumers those who are quite sure this problem remains unsettled, and for the very excellent reason that current investigation of it is still costing a lot of money and causing nightly headaches.

This does not mean that progress is not being made daily in knowledge and experience which permits the intelligent control of carbide precipitation and the hazards of its consequence, and enables the 18-8 alloys to continuously find an ever widening field of usefulness. But it does signify reluctance, for excellent reasons, to admit the implication that merely adding a mite of a "stabilizing" element to the alloys definitely disposes of the problem.

Within the writer's experience the phenomenon of carbide precipitation is a profoundly complex one. Even to define it taxes the ingenuity. Essentially, it appears that carbon dissolved in the austenite and normally retained in supersaturated solution at room temperatures, is precipitated out of solution in the form of carbides usually assumed to be chromium carbides, by exposure to heat within the range of temperatures variously placed between 700° and 1600° F. The mere existence of carbide precipitation per se is not evidence of "intercrystalline embrittlement." Sensitized alloys may still retain their attractive appearance, as well as a substantial part of their resistance to many corrosive influences, and their physical strength and toughness. It is only when precipitated carbides are associated intimately with certain corrosive conditions that serious trouble ensues. Then may be seen various manifestations of intercrystalline attack ranging in severity from mere discoloration to physical disintegration.

Unfortunately, carbide precipitation is not a "go or no-go" proposition. It varies from the faintest perceptible incipient condition to the other extreme, depending upon many factors, the most important of which are composition (specifically carbon and chromium content, and chromium-nickel ratio), and condition of heat treatment. Furthermore, the exact mechanism whereby carbides, few or many, are precipitated affects their manner of distribution, and this is quite generally thought to be a potent influence in determining the consequences. Since the practical significance of carbide precipitation resides in the varying effects it has on the behavior of the 18-8 alloys in each specific corrosive environment—an unnumbered variety of conditions and effects—it is hardly to be expected that the mere addition of a "stabilizing" element yields the one final answer. In fact even the advocates of this solution to the problem admit frankly that precautionary "stabilizing" treatments of the special alloys are required to reap full benefit.

Although the value of the special "stabilized" alloys is unreservedly admitted for specific types of corrosion resisting service, it should be recognized that their use places an added expense burden upon the consumer, and often puts off till another day the conquest of a new application. A somewhat different attitude toward this problem is maintained by that group in the industry who are devoting every effort toward advancing the day of cheaper Stainless Steels, who have, with gratifying success, resorted to new metallurgical methods for advancing control of carbon content, the one arch ally of carbide precipitation in the 18-8 steels, and who are, by analyzing each type of corrosion problem separately according to its nature, offering a satisfactory and economically sound solution, which except for certain rigorous types of service renders unnecessary the use of special "stabilizing" additions.

In view of these considerations, and of other ways known to metallurgists in the industry by which carbide precipitation can be controlled and manipulated without resorting to "stabilizing" elements, and of the possible adverse effect "stabilizing" elements may have on general corrosion resistance, is it not proper to ask that they be accorded due recognition by so influential an authority as the author?

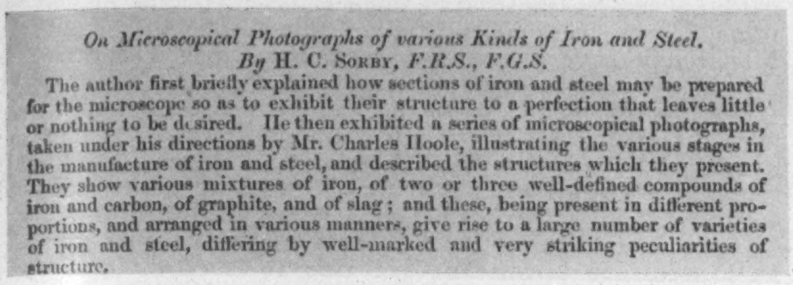
W. B. ARNESS,
Rustless Iron Corporation of America

Baltimore,
Oct. 12, 1934.

Sorby

Editor, METALS & ALLOYS:

It is now seventy years since Dr. H. Clifton Sorby lectured before the Sheffield Literary and Philosophical Society on a new method of illustrating the structure of various kinds of "blister steel" by nature printing. Of this paper no trace exists. Sir Robert Hadfield suggests, however, that it was presented to the Natural Science Section of the Society, but that no copy of it was kept. During the same year, Sorby communicated the results of his work at the Bath meeting of the British Association for the Advancement of Science. A photographic reproduction of the abstract of this communication is attached hereto.

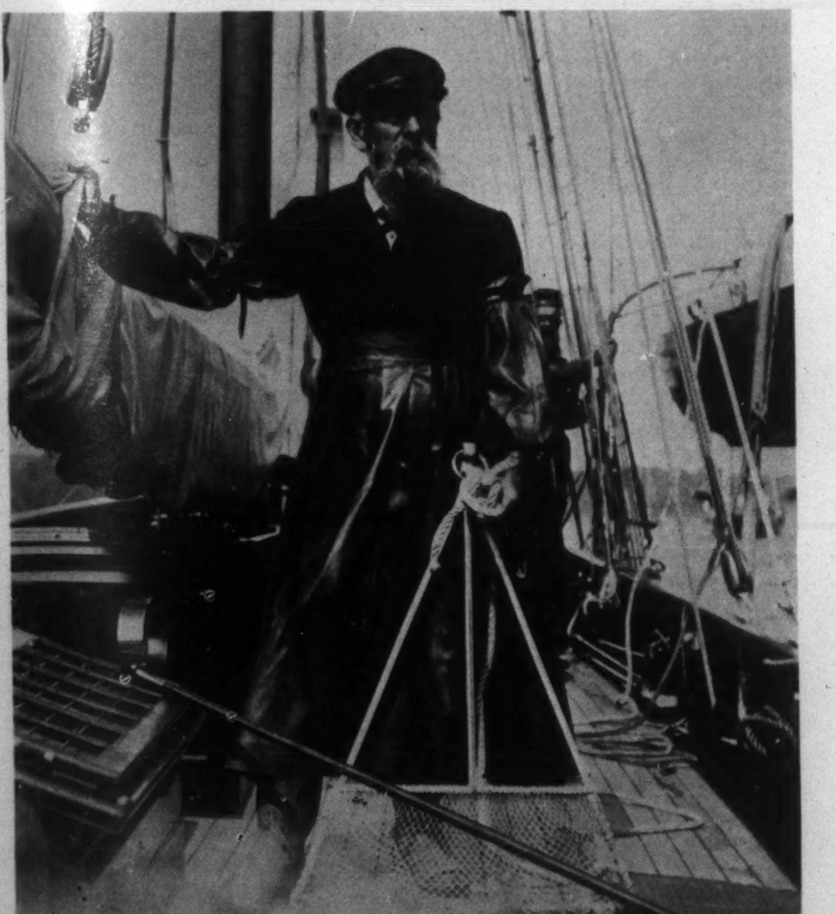


On Microscopical Photographs of various Kinds of Iron and Steel.
By H. C. Sorby, *F.R.S., F.G.S.*

The author first briefly explained how sections of iron and steel may be prepared for the microscope so as to exhibit their structure to a perfection that leaves little or nothing to be desired. He then exhibited a series of microscopical photographs, taken under his directions by Mr. Charles Hoole, illustrating the various stages in the manufacture of iron and steel, and described the structures which they present. They show various mixtures of iron, of two or three well-defined compounds of iron and carbon, of graphite, and of slag; and these, being present in different proportions, and arranged in various manners, give rise to a large number of varieties of iron and steel, differing by well-marked and very striking peculiarities of structure.

(Courtesy Mr. Bernard Collitt,
Metallurgist, Jenkins Bros., Montreal.)

In this connection it may be of interest to reproduce what I believe to be a hitherto unpublished photograph of "the father of modern petrography," as he has been called. This photograph was made (under the writer's direction) from a snapshot which was in the possession of a member of the Sorby family resident in Canada. It represents Dr. Sorby in surroundings somewhat unusual for a scientist interested in such things as metals and minerals. It appears, however, that he was wont to spend quite a considerable amount of his spare time in sailing in a boat of his own on the North Sea. It is more than probable, therefore, that this photograph represents him standing on the deck of his vessel.



The use to which Dr. Sorby put the net and the long-handled dipper that are shown is unknown to the writer, though it is not impossible that he may have been interested in obtaining marine specimens for examination under the microscope he so loved to use. It may be worth mentioning here that Professor Judd, who was a friend of Sorby, remarked: "You speak of Sorby's laboratory. All his work, when I knew him, was done in a private room in his house; there everything was as simple as Wollaston's—a table with his microscope, and a few bits of apparatus lying about." (Sir Robert Hadfield, *Transactions, Faraday Society,* Vol. 16, 1920-21, pages 114-118.)

Toronto,
Oct. 17, 1934.

O. W. ELLIS,
Ontario Research Foundation

New Steel Making Reagents?

Editor, Metals & Alloys:

The genial Russian, Prof. B. S. Smoledski, whom I knew first many years ago when he spent a year in America, sent this little paper to me with the request that I correct the mistakes in English and submit it to you for publication. I have followed his request, except that I could not bring myself to alter some of his delightful Russianisms.

New Reagents for Steel Making

B. S. Smoledski
Professor of Physico-chemical Metallurgy,
— — — Technical Institute, Sonimsk

From the technical and advertising literature it is evident that some of the most useful properties of a steel depend upon the reagents used in finishing it. Almost every author and steel-maker has his own panacea for the ills of steel, and quotes numbers to show how much better his special brand-name of steel is than ordinary steel. Many of these panaceas have in recent years been brought insistingly to our attention in Russia, particularly by foreign experts and selling agents who told us so much of the truly wondrous results obtained in their own country, that we wished to try them. But these special reagents, coming from California and other foreign localities, were very rare and costly; therefore I conducted some explorations in search of cheap reagents for steel, which would be made in Russia from Russian minerals so that in this direction also we would be economically self-content. I now outline a few outcomes of these explorations and tests, believing that they will interest the steel-making capitalists who read your valuable paper.

In the Nerchinskii mountains I came upon a very large deposition of a new mineral which looked so promiseful that I immediately sent some of it home to be reduced in the electric furnace and tested as a deoxidant for steel. Its effect was so astonishing that I had it analyzed; but I was unwilling to believe the analyst until it was analyzed again by a notorious chemist whom I met while travelling through America eastward, on my way home, to meet some of your illustrious consulting experts and to learn all I could about new and wonderful things in steel. Both analysts were able to identify only a part of this mineral, and therefore they concluded that it comprises a new element; and this made me sure that it would be marvellous for steel-making. This new element I have named Curium, after the Curies, the discoverers of that other nonpareil element radium, and also because, as with radium, only very minute quantities are needed to produce its characteristic effects.

The physico-chemical explanation of the unique action of curium is as follows. Curium takes oxygen away from the iron, forming a curious ironical oxide, which at high temperatures is a liquid boiling at 1551° C. (uncorrected). Because of this, if the liquid steel is above this temperature when the curium is added, the curious oxide comes off as a gas and you get a live effervescent steel which rims well; if the steel is below this temperature, the oxide remains in the steel, and you get a steel which, though dead, is quite clean owing to the undertaking agency of the curium. If now a larger quantity of curium is added, as I recommend, it forms a fine alloy steel which I call a curate steel. This steel is very mild and so inoffensive that when polite and smooth it is not attacked by any of the ordinary common rude corrodants. Curate steel has thus a long life, and is to be preferred for public structures and buildings; it is not however satisfactory as a tool or machine steel, because it does not harden easily.

On this same journey I was lucky enough to find, on the south-easterly slopes of the Yablonoi mountains, a mineral which contains a new and very hardening element. It is element No. 43, which was predicted by my great countryman Mendelieff and called eka-manganese because he thought that it would be a close relative of manganese. Now that I have actually found it, I proposed to call it eureka-manganese. There is little need to tell the steel metallurgist, so imbued with the virtue of ordinary manganese in hardening steel, that this new eureka cousin is a much more potent alloying element. Besides it is a better deoxidizer and desulphurizer, verily better in all ways, than manganese; only it will cost more because it has to be brought so far and to pass through so many hands. The present supply is not large, but we have enough to make all the special hardened steel we need for the present.

I wish to mention also a third new reagent of another favored type—namely one which, when added to the slag, helps it to take from the liquid steel all the undesirable elements, such as sulphur, phosphorus and tin, but leaves in all the useful proletarian elements and does not damage the refractories. This material I found, on this same very successful journey, at a place called Bastr, not far from Lake Baikal. It is a strange coincidence that the main basic constituents of this mineral, when freed from the gangue, are barium and strontium together with some alkali metals notably caesium. This coincidence led me to call this substance Bastr, and to denote steel made by use of this reagent by a name of which the English equivalent would be bastred steel. I am forming a company to develop this material in Russia, and am very open to propositions for exploiting it in America, which should be easy since it has incredulous financial talking-points.

In this brief communication I have given only the highlights on these astonishing reagents, neglecting the baser details. Any reader with doubtful questions can send them through the Editor to me; but he may have to wait for an answer for I am just starting out on another fancy tour of exploration.

Editor's Note

While the announcement* over ten years ago of Ferro Manureium has somewhat preempted the field that would be occupied by other reagents of its general type for steel making, alleged improvements on this basic discovery should be of interest to our readers. Apparently Ferro Manureium was not covered by patents, so it was to be expected that other inventors and investigators would enter so alluring a field. Some of those who have tilled this field in the interim since the epoch-making announcement of Ferro Manureium have hesitated to announce their discoveries in the technical pages of our journals. Not so Prof. Smoledski.

We are indebted both to the learned professor and to the mutual friend who corrected the announcement so as to make it more intelligible to English-speaking readers. We regret the desire of this mutual friend to remain anonymous—all we can say is, you'd be surprised if we named him.

It seems regrettable that the professor is not to be immediately accessible because of the tour referred to in his last paragraph. If this tour brings him to the U. S., perhaps he might be induced to go to Washington as a brain-truster for such brief time as might be required for him to put the steel industry on its feet again. His reference to the proletarian elements should qualify him as a technical adviser at least, though perhaps merely the Red point of view, rather than the active participation of Red planners, is all that is to be utilized for the moment. However, we feel sure that he would be a welcome addition to the brain trust in some capacity.

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* *Transactions, A.S.S.T.*, Box Bulletin Supplement, June, 1923, pages 46-47.

J. C. Lincoln Awarded Samuel Wylie Miller Medal

The American Welding Society today awarded the Samuel Wylie Miller medal to John Cromwell Lincoln, Chairman of the Board, The Lincoln Electric Company, Cleveand, Ohio, in recognition of his great contributions to the advancement of the science of electric fusion welding.

Born July 17, 1866 in Painesville, Ohio, J. C. Lincoln received his elementary education in the place of his birth, after which he attended Ohio State University, and received a degree in electrical engineering. Joining the staff of Charles F. Brush, inventor of the arc light, in 1888, Lincoln early gained experience with the phenomena of the electric arc. Later he became affiliated with the Elliott-Lincoln Electric Company, one of the pioneer manufacturers of electric motors. In 1896 with this company as a nucleus, he formed the present Lincoln Electric Company, Cleveland, Ohio. Under his direction this company produced in 1907 the first variable voltage arc welding machine. Two years later as a direct result of Lincoln's efforts, the first redesign of a cast iron product for arc welded steel construction was made. In 1916 Mr. Lincoln was the first to carry the electric arc into the structural field, where he directed the application of the process in the remodeling of an industrial structure. A year later in conjunction with the U. S. Government, he established the first school for training welding operators. His company has conducted this school continuously since that time, and has given thorough instruction to many thousands of students in the application of the process.

Mehl Awarded John Scott Medal

Dr. Robert F. Mehl, director of the Metals Research Laboratory at the Carnegie Institute of Technology and a member of the Editorial Advisory Board of METALS & ALLOYS has been awarded the John Scott Medal by the Philadelphia Board of City Trust, administrator of the fund, "for his discovery of a method of taking pictures through great thicknesses of steel to determine internal defects."

Erratum

In the article "Crystal Structure as a Guide in The Working of Magnesium Alloys" which appeared in the July 1934 issue, please note the following correction. In Fig. 12 under the headings "Case I" and "Case II" the column sub-heads "Tension" and "Compression" were interchanged; i.e., the two columns headed "Tension" should be "Compression," and vice versa.

Arnold Lenz Awarded Whiting Medal by A.F.A.

Arnold Lenz was awarded the Whiting medal at the annual convention of the American Foundrymen's Association for his conspicuous contributions to the foundry industry. He is a practical foundryman who worked his way up through the jobs of molder, coremaker, and melter, since he started out as an apprentice over 30 years ago. Mr. Lenz is now Assistant Manufacturing Manager in charge of the Flint, Bay City, and Saginaw plants of the Chevrolet Motor Co. Born in Hauingen, Germany, in 1888, Arnold Lenz was apprenticed at the age of 14 to the firm of Sarsin, Staehlin & Co., Haagen. Displaying even in those early years the determination which has made him one of this country's foremost founders, he attended night school during the four years of his apprenticeship. When he came to America in 1906, he spent two years working his way through New York State Normal School at Fredonia, New York.

In 1908, Mr. Lenz entered the employ of the Browning Foundry Co., at Ravenna, Ohio, as molder. In May 1916, he became an instructor in the foundry of the Buick Motor Co. in Flint, Mich. That same year, he was promoted to general foundry foreman and then to assistant superintendent. After a year spent as assistant to the manager of The Aluminum Casting Co., in Detroit, he returned to General Motors Corp. as superintendent of their gray iron foundry in Saginaw, then under construction. Since that time, he has held increasingly responsible positions with the General Motors Corporation.

Applied Mechanics Journal

The American Society of Mechanical Engineers has decided to publish in four quarterly issues beginning 1935, a "Journal of Applied Mechanics." The Journal will contain papers on Applied Mechanics which have been presented before the Applied Mechanics Division of the Society, besides other papers not so presented, reviews of pertinent literature and notes on important developments. An Editorial Board will be appointed, consisting of Specialists covering the different branches of the field of Applied Mechanics, i.e., Elasticity, Plasticity, Strength of Materials, Vibration, Aerodynamics, Thermodynamics, Film Lubrication and Electro-mechanics. The Journal will be sold to non-members at $5 per annum.

H. V. Glunz has been appointed General Manager of Operations of the Ohio Ferro-Alloys Corporation, Canton, Ohio, effective as of October 15th, 1934. Mr. Glunz, a graduate of Ohio State University in 1915, has a broad steel experience, embracing particularly the production of quality alloy steels through the medium of open hearth or electric furnace.

ORE CONCENTRATION (1)

JOHN ATTWOOD, SECTION EDITOR

The Progress of Metallurgy. Irving A. Palmer. *Mines Magazine,* Vol. 24, Mar. 1934, pages 9-12. Brief discussion of the following processes: converting of copper matte, flotation process, electrothermic smelting of Al, cyanide process, sintering process, electrolytic extraction of Zn, and sulphuric acid leaching of oxide copper ores. Kz (1)

Bolivian Tin Mine. T. F. Adams. *Mines Magazine,* Vol. 24, May 1934. pages 12-13, 23. The steps used in concentrating the ore are discussed by means of a flow sheet. Kz (1

A New Molybdenum Ore Dressing Plant. *Engineering Progress,* Vol. 15, June 1934, pages 111-113. Some particular and new features of a molybdenum ore dressing plant in Morocco with a daily capacity of 100 tons of crude ore are described. The concentration rate is 1:79. The dressing is done almost entirely by human labor, the monthly output is about 25 tons of concentrate of over 85% molybdenite. Crushing and picking, and grinding and flotation plant are described. Ha (1)

Amenability of Various Iron Ores to Rigorous Concentration. S. R. B. Cooke. *Progress Reports—Metallurgical Division. 4. Studies in Direct Production of Iron and Steel from Ore. Bureau of Mines, Report of Investigations* No. 3229, May 1934, pages 7-32. Chemical analyses, mineragraphic analyses and concentration tests are reported on magnetite, from Wharton, N. J. (2 ores); Mineville, N. Y.; Cornwall, Pa.; Iron Springs, Utah; Hanover, N. Mex.; and Eastern Mesabi, Minn.; hematite from the Mesabi range, Minn. (4 ores); Vermilion range, Minn.; Cuyuna range, Minn.; Marquette range, Minn.; Wyo.; Ala.; Tenn.; and limonite from the Cuyuna range, Minn. and Central Tenn. AHE (1)

Crushing, Grinding & Plant Handling (1a)

The Modern Conception of the Energy Consumption in Crushing (Den moderna uppfatning av krossningsarbetet). Ernst Rothelius. *Teknisk Tidskrift* **(Section** *Bergsvetenskap)* Vol. 64, June 9, 1934, pages 41-45, and July 14, pages 49-53. A highly theoretical discussion of the subject, in which is presented a review of recent work in this field by various investigators. Conclusion is that the minimum energy required in crushing is a function of the bound surface energy in the new surfaces. Confirms the figures obtained by Gross & Zimmerley in their investigation of the problem, by which it has been made possible for the first time to determine the crushing efficiency with some degree of accuracy. BHS (1a)

Explosion Shattering of Iron Ores. John Gross. *Progress Reports Metallurgical Division. 4. Studies in Direct Production of Iron and Steel from Ore. United States Bureau of Mines, Report of Investigations* No. 3229, May 1934, pages 33-34. Explosion shattering produces less extremely fine material than ordinary crushing. Magnetic concentration of -100 mesh taconite gave Fe recovery original ore 30.5, ordinary grinding 40.9, explosion shattering 200 lbs. 48.8, 250 lbs. 49.2%. The grade of concentrate from explosion shattering is better than from ordinary grinding. AHE (1a)

Flotation (1c)

Gold Ore Treatment. Victor Edquist. *Chemical Engineering & Mining Review,* Vol. 26, July 5, 1934, page 384. A new Australian process consists of three stages: (1) solution of Au and Ag by cyanide solutions of standard strength, (2) the precipitation of the dissolved Au by the addition of a precipitant such as finely ground charcoal, and (3) removal of the precipitated Au by treatment of the pulp in standard flotation equipment. Results on large scale operation are not yet available. WHB (1c)

Effect of pH and Various Chemicals on the Flotation of Pyrrhotite. Gaichi Yamada & Muneo Muraoka. *Suiyokwai-shi,* Vol. 8, Mar. 15, 1934, pages 435-439. In Japanese. Yanahara (a Japanese mine) pyrrhotite ore, minus 65, plus 200 mesh, was used for the sample. The flotation reagent was a mixture of camphor blue oil and coal tar. Solutions of pH-value from 3 to 11 before flotation, were constant at pH 7.5 after flotation. The floatability of pyrrhotite is 2 or 3% in a mixture of powdered ore with natural water, about 100% in a solution of pH-value lower than 4.6-5, and about 0% in a solution of pH-value higher than 5. The effect of adding chemicals, e.g., $Fe_2(SO_4)_3$, $CuSO_4$, KCN, is very small. HN (1c)

Notes on the Use of Sodium Nitrate in Flotation. A. K. Burn. *Bulletin Institution Mining & Metallurgy* No. 359, Aug. 1934, 2 pages. In the flotation plant of the Cia. Minera de Tocopilla, sea water is used. Addition of 120 g. $NaNO_3$ per ton of feed had 2 favorable effects: (1) the sulfides are less affected by the almost colloidal slimes which occur in some of the ores and (2) it does away with the difficulty experienced in breaking down froth on the collecting tanks. The concentration assays Cu 28.76, Pb tr., Mo 0.11, Sb 0.0, Fe 30.02, Zn tr., Ni 0.05, Co 0.05, S 34.46, SO_3 0.47, Al_2O_3 0.94, MgO 0.36, CaO 0.95, SiO_2 3.02, and CO_2 0.75. AHE (1c)

Selective Flotation at Ridder (Russia). S. P. Aleksandrov. *Tzvetnuie Metallui,* No. 1, Jan. 1934, pages 59-93. Description of the flotation practice and development work at the Ridder concentration plants. The average ore (1933) contains approximately 3.1% Pb, 6.7% Zn, 0.6% Cu, 10.5 g. Ag/gross ton, and 61 g. Ag/gross ton. The flotation of lead is described in detail; numerous data are given. The flotation of Zn will be reported later. BND (1c)

Amalgamation, Cyanidation & Leaching (1e)

Chlorination in Non-ferrous and Gold Industry. D. M. Chizhikov & A. Yu. Brechstedt. *Tzvetnuie Metallui,* No. 5, June 1933, pages 24-37. (In Russian). Describes the results of a series of experiments made at the State Institute of Non-ferrous Metals (Russia) on the extraction of metals from both oxidized and sulphide Pb-Zn ores by chlorination. The samples of ores contained from 5 to 25% Pb, 2 to 14% Zn, 2 to 14% Fe, and 0.18 to 0.62% Cu. Some of the ores contained As (2.1 and 5.7%), Ag (225 to 280 g./gross ton), and traces of Au. Preliminary laboratory experiments showed that 90% of the metal content of previously calcined ore can be volatilized as chlorides by heating in dry Cl at 1000° for 4 hrs. Further experiments showed that by chlorination of oxidized ores at 900-1000°, using mixtures of Cl and H_2O, 95% of Zn and Pb can be converted into volatile chlorides At lower temperatures (about 700°) the major part of the Zn and Pb remains in the ore in the form of non-volatile chlorides. With the addition of 20% charcoal the temperature may be lowered to 600° with the conversion of 90% of Zn and Pb into volatile chlorides. In the case of sulphide and mixed ores the maximum extraction is obtained by 4 hr. treatment in a mixture of Cl and H_2O at 700°. BND (1e)

Cyaniding Auriferous Sulphides. Valentine T. O'Connell. *Chemical Engineering & Mining Review,* Vol. 26, July 5, 1934, pages 381-383. Details are given of the plant of Sulphide Gold, Ltd., N.S.W. WHB (1e)

ORE REDUCTION (2)

A. H. EMERY, SECTION EDITOR

Theory of Fusion Electrolysis (Zur Theorie der Schmelzflusselektrolyse). P. Drossbach. *Zeitschrift für Elektrochemie*, Vol. 40, July 1934, pages 370-375. During electrolysis in a molten mass (1) the metal is dissolved as "metal vapor" by the liquid layer adhering firmly to the cathode (this layer can be assumed to be saturated), (2) the "metal vapor" diffuses from this border layer into the moving liquid, and (3) the moving liquid carries the "metal vapor" along with it. The first 2 stages determine the concentration of the metal in the bath and the losses in current efficiency; they depend on temperature; current efficiency decreases with decreasing temperature. Energy consumption of the process = $PIt + I^2Rt$, where P is e.m.f. of polarization, I current, R ohmic resistance and t time. Ha (2)

Non-Ferrous (2a)

Production of Aluminum from Clay by the Aluminum Sulphide Process (Aluminiumgewinnung aus Ton nach dem Schwefelaluminiumverfahren). Freitag. *Werkstoffe und Korrosion,* Vol. 9, May 10, 1934, page 18. Al-sulphide made from ordinary clay by addition of carbon in the electric furnace is fused with rocksalt as flux. This is disintegrated by direct current electrolysis into S and Al; the disintegration voltage is 1 volt lower than the bauxite process. Present experiments are very promising. Ha (2a)

Contributions to the Question of Dressing Complex Zinc-Lead Ores with Sulphurous Acid (Beiträge zur Frage der Verarbeitung komplexer Zink-Blei-Vorkommen mit schwefliger Säure). E. Terres & G. Ruehl. *Angewandte Chemie*, Vol. 47, May 19, 1934, pages 332-334. The extraction of oxide Zn-Pb ores with sulphurous acid yields metal-bisulphites only. A new process to extract complex Zn-Pb ores with highly concentrated aqueous SO_2 solutions under high pressure and at temperatures which are higher than the critical temperature of solution of the system H_2O-SO_2 permits complete extraction with simultaneous production of Pb-sulphite-sulphate, Zn SO_4, Fe sulphate, and of metallic Cu and Ag. The diagrams of state of the ternary systems ZnO-H_2O-SO_2, CuO-H_2O-SO_2, FeO-H_2O-SO_2 and PbO-H_2O-SO_2 were developed to determine the action of SO_2 on the ore. At temperatures above 150° C. sulphurous acid decomposes: $3H_2SO_3 \longrightarrow 2H_2SO_4 + H_2O + S$ (the latter remains in the solution). The oxides of electropositive metals (Cu) are reduced to metal by SO_2, the oxides of electronegative metals (Zn, Pb, Fe) are converted into the sulphates, very likely over the sulphite, bisulphite, hyposulphate and tetra-thionate to the sulphate. Ha (2a)

Nickel Extraction by the Mond Process. *Industrial Chemist*, Vol. 10, July 1934, pages 253-264. Describes the Clydach Refinery of the Mond Nickel Co., Ltd. Flow sheets of the process are given. RAW (2a)

Ferrous (2b)

On the Behavior of Siderite during Roasting (Ueber das Verhalten des Spateisensteins bei der Röstung). W. Luyken & L. Kraeber. *Stahl und Eisen*, Vol. 54, April 12 1934, pages 361-364. The changes in siderite during roasting were determined chemically, by x-rays, and by magnetic measurements. On heating with the exclusion of air, siderite breaks down into a mixture of Fe_3O_4 and considerable FeO; CO and CO_2 are evolved. With access to air the FeO is oxidized to magnetic Fe_2O_3. SE (2b)

Review of British Blast Furnace Practice. W. S. Allen. *Iron & Steel Industry*, Vol. 7, Jan. 1934, pages 101-105. British blast furnace equipment and practice are reviewed. Attempts are made at increasing the efficiency of modern installations. CEJ (2b)

Blast-Furnace Practice. *Engineer,* Vol. 157, June 8, 1934, pages 587-589; *Engineering*, Vol. 137, June 8, 1934, page 663. Brief summary of report prepared by the Blast-Furnace Committee of the Iron and Steel Industrial Research Council presented for discussion at the annual meeting of the Iron and Steel Institute, May 31, 1934. LFM (2b)

Blast-Furnace Practice. Extract from Special Report No. 6. *Iron & Coal Trades Review*, Vol. 128, June 1, 1934, pages 870-874. The exhaustive report of the (British) Sub-Committee of the Blast-Furnace Committee of the Iron and Steel Industrial Research Council deals with practices in different districts in England and design and operation of blast-furnaces. Output of a furnace can be increased greatly by improved, graded and, if possible, concentrated ores. The resistance in a furnace to the flow of gases is of great influence on economy and output; a formula was developed from operating data and applied to several furnaces; it was found that those furnaces which operate most efficiently as regards fuel consumption and output show the lowest resistances. Ha (2b)

An Experimental Inquiry into the Interactions of Gases and Ore in the Blast Furnace. W. A. Bone, H. L. Saunders, N. Calvert & J. E. Rushbrooke. *Iron & Coal Trades Review*, Vol. 128, June 8, 1934, page 932. See *Metals & Alloys,* Vol. 5, Sept. 1934, page MA 430. Ha (2b)

Considerations on the Reduction-Mechanism of Iron Oxide (Betrachtungen über den Reduktionsmechanismus der Eisenoxyde). W. Baukloh & R. Durrer. *Stahl und Eisen*, Vol. 54, June 28, 1934, pages 673-676. General discussion. Some results of the effect of rate of gas flow on reduction of FeO and of reduction of FeO with N_2-H_2 and N_2-CO mixtures are given. SE (2b)

Equilibria and Velocities in Ore Reduction. Wm. A. Bone, H. L. Saunders & J. E. Rushbrooke. *Iron & Coal Trades Review,* Vol. 128, June 1, 1934, pages 877-879. The equilibria in the systems $Fe_xO_y + CO \leftrightarrows Fe_xO_{y-1} + CO_2$ at 1150° C., $Fe_xO_y + H_2 \leftrightarrows Fe_xO_{y-1} + H_2O$ at 450°-850° C., and relative velocities of ore reducing reactions $Fe_xO_y + CO \leftrightarrows Fe_xO_{y-1} + CO_2$ at 650°-1000° C. were determined experimentally. The results confirm previous investigations with respect to the endothermicity of the stage $Fe_3O_4 + CO \leftrightarrows 3FeO + CO_2$ and exothermicity of the final stage $FeO + CO \leftrightarrows Fe + CO_2$. New data for the H-reaction show endothermicity of both the $Fe_3O_4 + H_2 \leftrightarrows 3FeO + H_2O$ and the final $FeO + H_2 \leftrightarrows Fe + H_2O$ reactions; they also indicate that, whereas CO is a better reducing agent than H at temperatures below 850°, the reverse is the case at higher temperatures. The velocity of ore reduction as measured by the rate of O-removal diminishes progressively as the ore reduction proceeds and as the CO_2 content of the blast-furnace gas increases. The decrease is not always uniform and is influenced by the ratio CO/CO_2. An increase in velocity of blast-furnace gas from 4 to 16 ft./min. resulted in an increase in the relative rates of ore reduction at all temperatures investigated. Ha (2b)

Proposed Methods for Comparative Testing of Iron Ores. Wm. A. Bone, H. L. Saunders & N. Calvert. *Iron & Coal Trades Review*, Vol. 128, June 1, 1934, pages 875-877. The comparison of "reducibilities" of Fe ores is discussed; the best method is based on 2 reactions: (1) C deposition from $2CO \leftrightarrows C + CO_2$ in the upper region of the furnace at about 450° C. whereby the ore may be "impregnated" with finely divided C which at still higher temperatures acts as a powerful reducing agent, and (2) direct deoxidation of the ore by CO, i.e., $Fe_xO_y + CO \leftrightarrows Fe_xO_{y-1} + CO_2$, in the middle region of the furnace, for which a temperature of 750° C. was selected for comparison purposes. Charts were developed from ore analyses, time of contact of ore, fuel and gases, and percentage reduction; the lower the curve lies the more easily will the ore be reduced. The procedure is illustrated by results on 5 different ores. By studying the conditions obtaining inside the furnace the economy of blast-furnace operation may be improved. Ha (2b)

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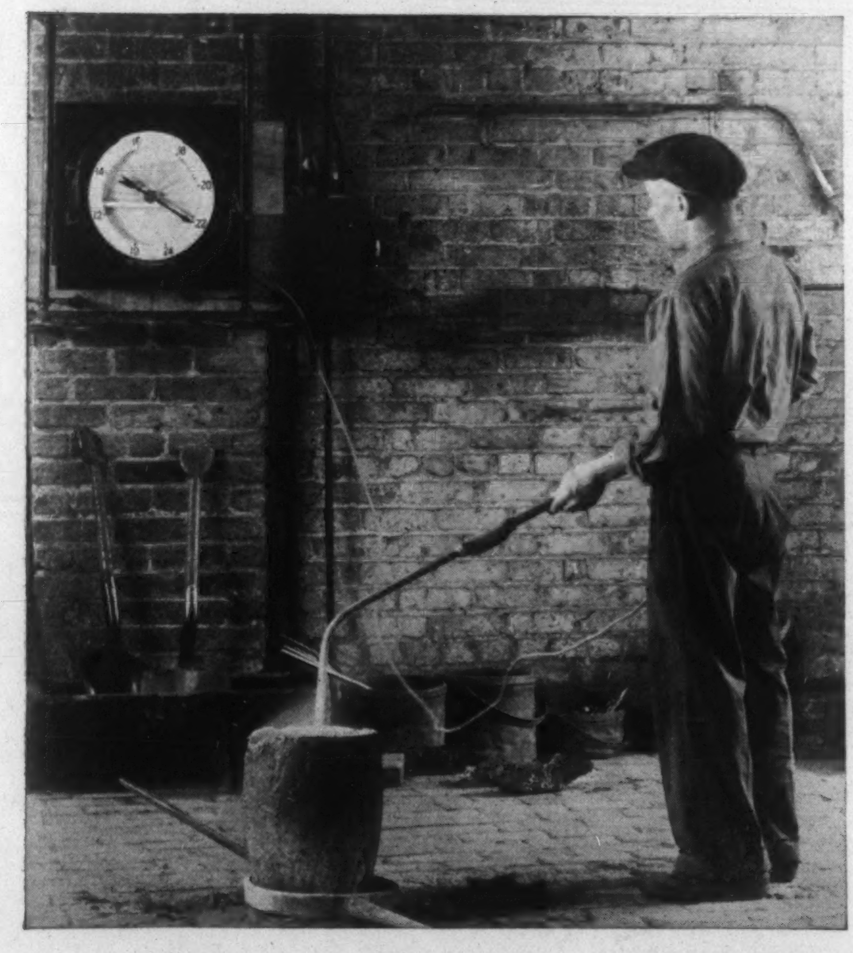

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MELTING, REFINING & CASTING (3)

Foundry Equipment. Volume II, part 1. N. P. AKSENOV. Gosudarstvennoje Naouchno-Technicheskoje Izdatelstvo, Moscow, 1933. Cardboard, 5¾ x 6¾ inches, 216 pages. Price 3.55 roubles. Very inferior paper and poor illustrations cannot detract from the interest of this book. It reads better than any text which the reviewer was able to consult. Being a description of molding machines it is written so that the reader not only obtains a clear impression of the apparatus in question but is fully informed of the basic principles underlying their functioning and the advantages and the negative features of them, both from technical and economic standpoints. One does not need to be either a foundryman or an accomplished mathematician to follow the presentation with perfect ease. The very simplicity of the narration reflects the profound knowledge of the writer permitting him to discard many details of interest to practical men and theoretical investigators, but having but a slight bearing on the moulding machines as such. The intended purpose, giving to the reader, any reader, a thorough understanding of them is fully achieved. The field is covered thoroughly, both the major types of machines and their subdivisions are given. With the exception of a few German books it would be difficult to find any which would be more suitable for general study or use in colleges than this one. (3) -B-

Foundry Practice. M. G. EVANGOULOV. 6th edition. Gosudarstvennoe Nauchno-Technicheskoe Izdatelstvo. Moscow. 1933. Cloth, 6 x 9 inches 452 pages. Price 7.10 roubles. Textbook writing imposes specific and definite requirements. Overcrowded curricula limit their size. Prospective readers are not sufficiently acquainted with the subject to permit any other method of presentation than by the gradual advance from the elements. The subject matter must be adjusted in an order leading to a maximum understanding both of the whole and of any given point. One has to overcome here the natural tendency for expressing personal opinions or for critical examination of conflicting views without, however, affecting the completeness of the final picture. Not being easy with abstract subjects, the task becomes particularly difficult in application to the arts in which a few major postulates are buried in a maze of details. Only a long and successful teaching experience permits one to achieve the quality of the present work. The material offered is excellently balanced, comprehensive theoretical part is thorough and precise; descriptions and data are complete, accurate and up to date. The book gives to a student a full and clear picture of the whole art of the modern founding. (3) -B-

The Field for Materials Handling in Semi-Production Foundries. RALPH G. WIELAND. *Transactions American Foundrymen's Association*, Vol. 5, Apr. 1934, pages 481-487. Semi-production or jobbing foundries melting from 10 to 50 tons per day and employing from 10 to 70 molders may economically use equipment for materials-handling. Cranes or continuous belts may substitute for the more expensive overhead switches for unloading raw materials. Mechanical cupola charging equipment warranted for melting of over 30 tons per day. Monorails or cranes almost essential for distribution of molten metal. A flexible overhead system of hand-handling and conditioning is most convenient. Rolls, monorails or trucks facilitate handling castings through the cleaning, grinding, chipping, inspecting and shipping departments. Average cost of installing complete equipment for continuous molding has been from $2000 to $3000 per molders floor. CEJ (3)

Correct Design with Respect to Shape and Pouring (Ueber form- und giessgerechte Konstruktion). J. KUESTER. *Die Giesscrei*, Vol. 21, May 11, 1934, pages 195-200. Coöperation between designer and foundry is emphasized; examples illustrate—wrong and correct design given side by side—how by correct design cheaper and simpler castings can be produced. Internal stresses can be avoided by suitable foundry methods. Ha (3)

Dressing Molding Sand (Wie soll Formsand aufbereitet werden?). R. BERGER. *Zeitschrift für die gesamte Giessereipraxis*, Vol. 55, Apr. 29, 1934, pages 178-186. Discusses requirements that efficient modern sand molding machines have to meet. Results of experiments on physical properties of molding sand prepared with "Intensiv" dressing machine of Badische Maschinenfabrik are given. It was found that the binding strength of used molding sand, regenerated by addition of a certain amount of virgin sand was increased by dressing in this machine by ½ as compared with that of molding sand prepared in common mixing mill. Construction and method of operation of a number of new German sand dressing machines is considered at length. GN (3)

American Specifications for Gray Iron Castings (Spécifications Américaines pour les Pièces de Fonte Grises). *Bulletin de l'Association Technique de Fonderie*, Vol. 8, May 1934, pages 205-206. The specifications published in Oct. 1932 *Transactions of the American Foundrymen's Association* are translated and discussed as to their differences with European practice. Ha (3)

Non-Ferrous (3a)

G. L. CRAIG, SECTION EDITOR

Molding Condenser Castings. J. H. EASTHAM. *Foundry*, Vol. 61, Nov. 1933, pages 14-15, 40. Describes molding details and flash equipment for casting outside of the usual range. VSP (3a)

Pressure Casting (Le Moulage sous Pression). KESSLER. *Revue de Fonderie Moderne*, Vol. 28, June 10, 1934, pages 157-162. The process of injecting a metal in liquid or pasty state into a metal mold is called pressure (die) casting; the different methods and equipment used are discussed. Materials which are frequently cast in this manner are heavy alloys with low melting points (alloys with a base of Pb, Sn and Zn), light metals with high melting temperatures (alloys with a base of Al and Mg), and heavy alloys with higher melting points (Cu alloys, especially brasses, and Ag). The advantages to be derived are reduced machining costs, ease of casting complicated shapes with clean surfaces. Ha (3a)

Recent Developments in Brass Die-Casting Methods. HERBERT CHASE. *Machinery*, N. Y., Vol. 40, July 1934, pages 653-655. Compositions and properties of ordinary yellow brass and 3 other Cu-base alloys especially adapted for die-casting, machinery and process, and the design of dies for brass casting and materials used in their construction are described in detail. Ha (3a)

A Production Casting Die. ESTEBAN. *Mechanical World & Engineering Record*, Vol. 95, May 4, 1934, page 425. The Zn-Al-Cu alloys now employed for pressure die-castings are ideal for ornamental metalwork. A highly efficient and productive die for die-casting articles of this kind is described. Kz (3a)

Developments in Modern Foundry Materials and Equipment. J. W. GARDOM. *Iron & Steel Industry*, Vol. 7, Jan. 1934, pages 107-111, 153. Requirements of modern specifications call for more skilled technical and metallurgical control. Increased efficiency of cupola furnaces together with the use of the "batch" furnace of the rotary pulverized coal or oil fired type or high frequency induction electric furnace are prevalent. Continuous core drying ovens of vertical type and core blowing machines aid production of quality cores. Molding machines with individual power units tend to increase flexibility of operation. Standard practice with standardized apparatus for testing strength, permeability and moisture of sands have been recommended. CEJ (3a)

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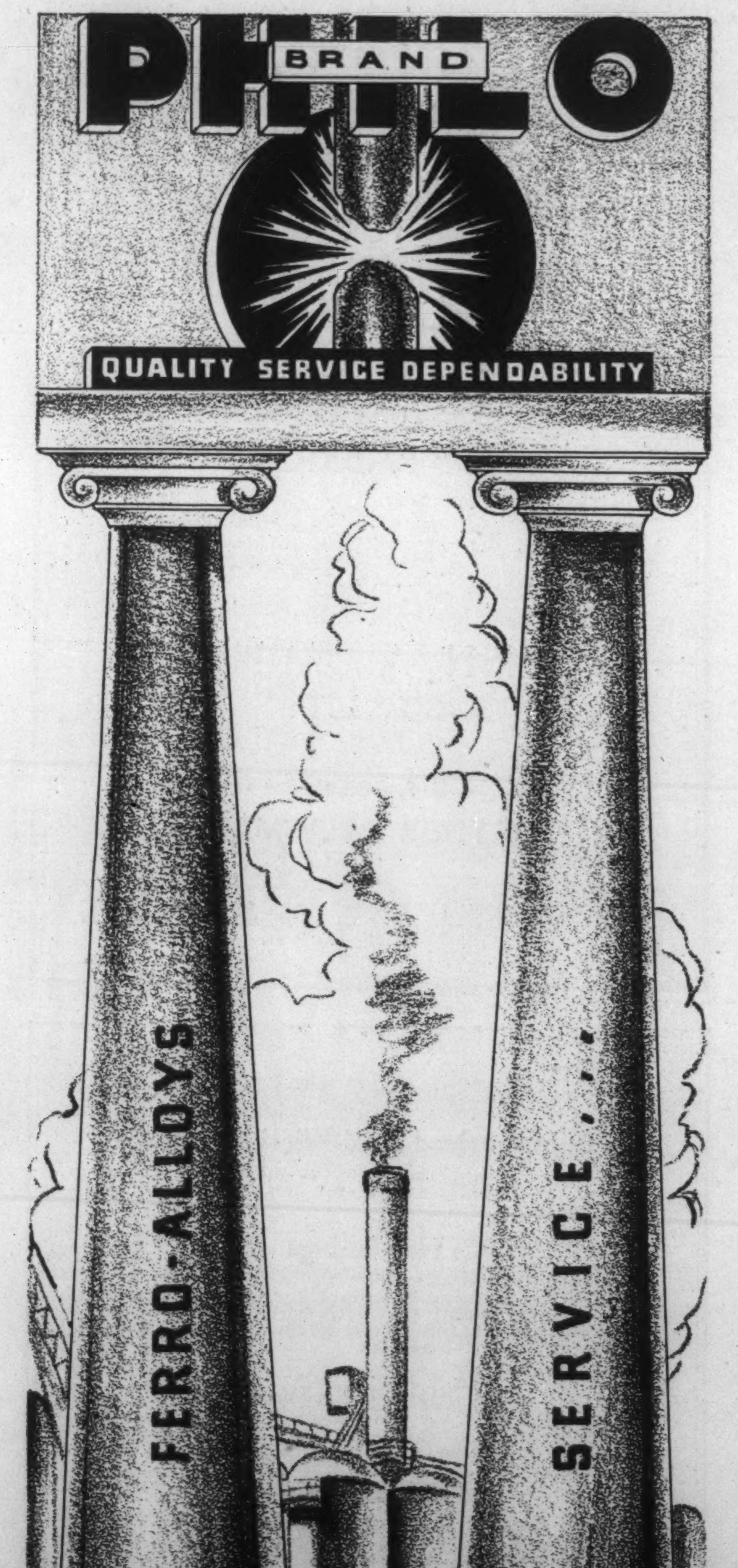

Ferrous (3b)

C. H. HERTY, SECTION EDITOR

The Oxidation Stages of Iron in Slags in Relation to Composition, Temperature, and Furnace Atmosphere (Die Oxydationsstufen des Eisens in Schlachen in Abhängigkeit von der chemischen Zusammensetzung, der Temperatur und der Ofenatmosphäre). H. Salmang & J. Kaltenbach. *Archiv für das Eisenhüttenwesen,* Vol. 8, July 1934, pages 9-13. The oxidation stages of Fe were studied in the systems FeO-Fe_2O_3-SiO_2; FeO-CaO-Fe_2O_3-SiO_2; FeO-Fe_2O_3-Al_2O_3-SiO_2; FeO-CaO-Fe_2O_3-Al_2O_3-SiO_2; in relation to the chemical composition, at 1230, 1320, and 1410°C in oxidizing atmospheres. CaO favors Fe_2O_3 formation, SiO_2 and Al_2O_3 favor FeO. In CaO-FeO-Fe_2O_3-SiO_2 melts the formation of FeO. Fe_2O_3 is dependent on the ratio CaO/SiO_2. Rise in temperature favors the dissociation of the slag components and likewise FeO formation. Increasing the temperature range 1230-1320°C to 1320-1410°C increased the dissociation 50%. In the slag systems studied 1 part CaO is equivalent in wt. % to 1.3 parts FeO and 1 part SiO_2 to 1.4 parts Fe_2O_3. SE (3b)

Cast Iron Charge and Cast Iron Properties (Gusseisengattierung und Gusseiseneigenschaften). A. Vaeth. *Die Giesserei,* Vol. 21, May 25, 1934, pages 216-223. The common defects in gray iron are investigated in their relation to making up the cupola charge. Defects are 1. leaky, spongy casting, 2. hard spots which can not be machined, 3. deviation from prescribed hardness and strength, 4. deviation from prescribed structure. Properties can be influenced, even for the same composition, by different wall thicknesses, raw materials and scrap added, method of melting, and even weather conditions. The cast wedge specimen offers the simplest and quickest means to ascertain tendency to form pipes, and to ferritic-eutectic solidification instead of the normal pearlitic solidification. The most characteristic structures of a gray iron are 1, the metastable structure, consisting of the ledeburite eutectic; it is caused by rapid cooling. 2. Structure with formation of eutectic graphite and principal mass rich in ferrite, whereby the graphite is arranged usually purely eutectically and often dendritically; also the phosphide eutectic is dendritic. The grain is caused by rapid, but not too sudden cooling. 3. The normal pearlitic structure with little ferrite and veiny graphite; this occurs regularly in cast iron with wall thicknesses not over 6 mm. and not too high Si content. 4. Structure with coarse graphite and ferrite in the mass; it occurs in irons with high Si content and too slow solidification velocity. It is explained how the cast wedge shows all possible structures and how they can be derived by metallographic examination. The formation of eutectic graphite is most important for the properties of a casting; this formation causes a reversal of hardness in thin walls, they are softer than thick walls. The reversal of hardness occurs particularly in castings with many cores. Stronger walls show variations of hardness over their section which are caused by disintegration of pearlite by action of gases. The phase of graphite and the gas content of the melt determine piping and stability of pearlite. The tests results are given in detail for various compositions of the burden. In order to obtain a sound casting a burden is required which has little tendency to form nests of eutectic graphite, must be tapped at proper temperature and poured correctly taking into account shape of casting. 12 references. Ha (3b)

Economic Operation of Electric Arc Furnaces (La Conduite Rationalle des Fours Electriques à Arc) E. Decherf. *Revue Universelle des Mines,* Series 8, Vol. X, Jan. 1, 1934, pages 1-6; Jan. 15, 1934, pages 37-44. See *Metals & Alloys,* Vol. 5, Mar. 1934, page MA 109. Ha (3b)

Molding of A Cog Wheel, 3400 mm. in Diameter (Wie wird ein Kammrad, 3400 mm. Durchmesser, geformt?) *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, Feb. 4, 1934, pages 57-59. Detailed illustrated discussion of molding procedure of such a wheel as used in power transmission of turbines. GN (3b)

Molding Guide Wheel of a Turbo-Compressor (Das Formen eines Leitrades für einen Turbokompressor) *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, Feb. 18, 1934, pages 79-81. Discussion of procedure followed in molding in flask with one pattern above mentioned part. Making of cores required is also described. Casting is briefly outlined. GN (3b)

Molding and Casting of a Cylinder Cover (Formen und Giessen eines Zylinderdeckels nach Schablone [Unterteil ist Dauerform]) *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, Jan. 7, 1934, pages 17-20. Paper discusses at length arrangement and joining of a loam mold of the cylinder cover of a large gas engine under the following headings (1) arrangement of mold, (2) core boxes and cores, (3) joining of single parts of mold. Casting procedure is briefly considered. GN (3b)

Micro-chemical Analysis of Electrolytically Isolated Slag Inclusions in Steel (Über die mikrochemische Analyse von elektrolytisch isolierten Schlackeneinschlüssen im Stahl. Vorläufige Mitteilung) H. Alber & C. Benedicks. *Arkiv för Kemi, Mineralogi och Geologi,* Vol. 11, Apr. 1933, 11 pages. The electrolytic method of R. Treje and C. Benedicks, which permits a complete isolation of slag inclusions in steel, yields relatively small slag quantities of about 5-10 mg. in 24 hr. electrolysis time. The analysis must, therefore, be carried out micro-analytically. Si, Al, Fe and Mn are determined separately from S. Data presented show a satisfactory accuracy of the gravimetric and micro-analysis of Si, Al, Fe, volumetric analysis of Fe and Mn, and colorimetric determination of Mn. WH (3b)

Finishing the Heat of Steel. Pt. XIX-XX. J. H. Hruska. *Blast Furnace & Steel Plant,* Vol. 22, Apr. 1934, pages 212-213; May 1934, pages 268-269,275. Includes bibliography of 10 references. Discusses crystallization of steel. MS (3b)

Effect of Mould Condition upon Cast Iron. A. Väth. *Foundry Trade Journal,* Vol. 50, Mar. 22, 1934, page 195. Extended abstract of article by Väth in *Die Giesserei.* See "Dependence of Gray Iron on Quality of the Mold," *Metals & Alloys,* Vol. 5, June 1934, page MA 288. OWE (3b)

Producing High-Speed Steel in the Coreless Induction Furnace. Peter Bardenheuer & Werner Bottenberg. *Steel,* Vol. 94, May 28, 1934, pages 45-46, 48-49; June 25, 1934, pages 41-42, 44-45; Vol. 95, July 9, 1934, pages 41-42, 44-45. Translated by William Adam, Jr., from *Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung zu Düsseldorf,* Vol. 14, No. 7. See *Metals & Alloys,* Vol. 4, July 1933, page MA 220. MS (3b)

Sulphur in the Cupola. Iw. Trifinow. *Foundry Trade Journal,* Vol. 49, Dec. 7, 1933, page 328. Extended abstract of paper which appeared in *Die Giesserei,* Nov. 10, 1933. See "Sulphur in the Operation of a Cupola Furnace," *Metals & Alloys,* Vol. 5, June 1934, page MA 252. OWE (3b)

Hot Blast Cupolas. F. K. Vial. *Foundry Trade Journal,* Vol. 49, Sept. 21, 1933, page 165. See "Preheating the Cupola Blast," *Metals & Alloys,* Vol. 5, Apr. 1934, page MA 128. OWE (3b)

A Few Remarks on Gating and Molding of Bulky Malleable Castings (Einiges über Anschneiden und Formen sperriger Tempergussstücke) W. Schneider. *Zeitschrift für die gesamte Geissereipraxis,* Vol. 55, Jan. 7, 1934, pages 7-9. After dealing with defects occurring in bulky malleable castings various remedies are discussed. In examples author shows that common method of avoiding pipe formation in large sections of malleable castings by chilling parts or similar cooling devices are not successful in general. Best method is to arrange large suction ports as the case of a shop window frame goes to show. In another instance cracks occurring in malleable cast Fe valves were found to be due to poor gas removal. By inserting wax strings in valve core failure was eliminated. GN (3b)

Production of Tool Steel in High Frequency Induction Furnace (Die Erzeugung von Werkzeugstahl im kernlosen Induktionsofen). P. BARDENHEUER & W. BOTTENBERG. *Archiv für das Eisenhüttenwesen,* Vol. 8, July 1934, pages 1-8. 300 kg. high frequency induction furnace melts of 1% C tool steel were made in acid crucibles. Some of the melts were deoxidized with Fe Mn and Fe Si shortly before pouring, others by reduction of Si from the slag. The latter method gave a finer grained type of steel as indicated by fracture tests after quenching from as high as 960°C and by the number of repeated quenchings withstood without cracking. Good practice for this type of steel is discussed, repeatedly changing the slag and replacing it with glass to prevent undue oxidation of the melt, being recommended. SE (3b)

Further Studies on the Metallurgy of the Basic Bessemer Process (Weitere Untersuchungen über den metallurgischen Verlauf des Thomasverfahrens). P. BARDENHEUER & G. THANHEISER. *Stahl und Eisen,* Vol. 54, July 12, 1934, pages 725-728. Graphs of 3 basic bessemer melts give the rate of oxidation of the different metalloids during the blow and the pickup in O_2 and N_2 in the bath. Analyses of the free lime in the slag indicated when this changed from acid to basic. The effect of this change on the rate of oxidation of the metalloids is discussed. SE (3b)

Products Used to Obtain a Better Skin on Castings (Décapants). Technical Committee of the Belgian Foundry Association. *La Fonderie Belge,* Vol. 3, Mar.-Apr. 1934, pages 31-36. At the shake out station a good separation of sand from castings is obtained by the following methods. (1) Using a more refractory sand. (2) Application of a liquid coating on the mold surfaces, the mold being then dried. (3) Sprinkling of pulverized matter on mold surfaces. (4) Applying on mold surface fume products of a flame directed on to the surfaces. (5) Addition to the sand of a given quantity of finely pulverized coal. Respective value of processes and mechanism of action of each are discussed: (1) Vegetable blacking: or charcoal which is sprinkled on mold surfaces and used in green sand practice. It is shown that unfortunately charcoal sold by manufacturers varies largely as to composition, volatile matters ranging from 6 to 19% in samples studied. (2) Dry sand blacking applied in the liquid state on molds in dry sand practice. This is generally made up as follows: charcoal 75%, graphite 15%, refractory clay 10% (in weight). Quality of such products varies largely with their volatile content. A better separation of sand from casting being obtained when volatile content is high. A correct application of such blacking is necessary, it is for instance, bad practice to apply it on wet mold surfaces. A layer of linseed oil over blacked surfaces some time after blacking can give good results only when this layer is thin. (3) Mineral blacking, or finely pulverized charcoal, is mixed with foundry sand. Best results are obtained with coal of high volatile matter content very finely pulverized. It must however be kept in mind that charcoal decreases permeability of molding sand and releases volatile matters which can act as mold gases in causing defects. (4) Graphite and plumbago. These products which are extracted in mines are applied on mold surfaces and act more or less efficiently according to their ash content. FR (3b)

Decreasing Production Costs by Dispensing With Cores (Verminderung der Gestehungskosten durch Fortfall der Kernarbeit). *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, June 24, 1934, pages 263-264. In comparing, for certain castings, molding with and without cores the paper summarizes the following advantages of coreless molding: (1) production costs are considerably lowered, (2) 10-15% in weight can be saved since corefree castings are then made on molding machines, (3) castings are more accurate and therefore (4) additional material for subsequent machining can be saved which also means (5) saving of time. GN (3b)

Repairs of Open Hearth Furnace without Delay (Reparaturen am Siemens-Martin-Ofen ohne Betriebsstörung). *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, June 10, 1934, pages 239-241. For rapid repair of open hearth furnace arches a few simple devices are described that make possible repair in such a short time that operation of furnace need not be interrupted. GN (3b)

Manufacturing of Quint Ovens by Wet Sand Casting Method (Die Herstellung von Quintöfen im Nassgussverfahren). A. FREITAG. *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, June 24, 1934, pages 257-260; July 8, 1934, pages 283-285. Quint ovens, the construction of which is first briefly described are manufactured in 4 sizes. The molding devices and molding itself are outlined in full detail, as making the mold of the case, making the cores and auxiliary parts, oven rings, etc. GN (3b)

Making the Mold of a Bayonet Frame (Die Herstellung der Form zu einem Bajonetrahmen). *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, May 13, 1934, pages 209-213. Paper discusses in detail molding procedure followed in making a large bayonet frame as used in steam engine and compressor construction. Casting weighed 6800 kg. and possessed a length of 5200 mm. Frame was molded in horizontal position. Casting procedure is finally briefly touched upon. GN (3b)

Making the Mold of an Evaporator Hood with Three Sweep Spindles (Herstellung der Form für eine Abdampfhaube mit drei Schablonenspindeln). *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, May 27. 1934, pages 229-231. Detailed description of the sweep molding procedure applied in molding the casting in question. GN (3b)

Modern Molding Machires for Economic Molding of Small and Medium Size Castings (Neuzeitliche Formmaschinen zum rationellen Formen von kleinen und mittleren Gussstücken). *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, Apr. 29, 1934, pages 174-176. A number of new German constructions of molding machines for mass production are described. GN (3b)

Soda Ash in the Iron Foundry. *Chemical Trade Journal & Chemical Engineer,* Vol. 94, Mar. 23, 1934, page 213. Abstract of a paper by N. L. Evans delivered before the Institute of British Foundrymen, Sheffield, Mar. 16, 1934, on the use of Na_2CO_3 for producing superior castings of grey iron, steel, brass and bronze. See "Use of Sodium Carbonate in Iron and Steel Works," *Metals & Alloys,* Vol. 5, Aug. 1934. page MA 385. JN (3b)

Soda Ash in the Iron Foundry. N. L. EVANS. *Chemical Trade Journal & Chemical Engineer,* Vol. 91, Dec. 2, 1932, pages 523-524; discussion, Dec. 9, 1932, page 550. Abridgement of paper read before joint meeting of British Cast Iron Research Association and Institute of British Foundrymen, held in London, Dec. 1, 1932. See "A Phase of Recent Research in Foundry Technique. Some Observations on the Use of Soda Ash," *Metals & Alloys,* Vol. 4, Nov. 1933, page MA 358. JN (3b)

New Metallurgical Methods (Nya metallurgiska Methoder). M. PERRIN. *Teknisk Tidskrift* (Section *Bergsvetenskap*), Vol. 64, June 9, 1934, pages 45-48; July 14, 1934, pages 54-56. Taken from *Revue de Metallurgie,* Jan. 1, 1933. See *Metals & Alloys,* Vol. 4, Dec. 1933, page MA 391. BHS (3b)

Theoretical and Practical Study of Melting in Cupolas (Etude Theorique et Practique de la Fusion aux Cubilots). A. POUMAY, JR. *La Fonderie Belge,* Vol. 3, Mar.-Apr. 1934, pages 37-38. See *Metals & Alloys,* Vol. 5, Aug. 1934. page MA 386. FR (3b)

Open-Hearth Steel Furnace Practice in 1933. H. C. WOOD. *Iron & Steel Industry,* Vol. 7, Jan. 1934, pages 119-120, 152. New installations lending increased output and reduced cost of manufacture are enumerated. Tendency is to simplify control by installing larger furnaces. CEJ (3b)

Residual Metals in Open Hearth Steel. JOHN D. SULLIVAN. *Metals & Alloys,* Vol. 5, July 1934, pages 145-146. Report of study of residual metals in open hearth steel covering 20 steel plants and period Mar. 1931 to Jan. 1934. WLC (3b)

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Shop Method for Determining Volume Changes in Cast Iron during Casting (Méthode de l'Atelier pour determiner les Variations de Volume dans la Fonte pendant la Coulée). E. J. Ash & C. M. Saeger. *Bulletin de l'Association Technique de Fonderie,* Vol. 8, May 1934, pages 202-204. Translation from transactions of American Foundrymen's Association, Aug. 1932, pages 188-195. See *Metals & Alloys,* Vol. 4, July 1933, page MA 222. Ha (3b)

The High-Frequency Induction Furnace. IX and X (Der Hochfrequenzofen, IX und X). P. Bardenheuer & W. Bottenberg. *Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung, Düsseldorf,* Vol. 16, No. 8, 1934, pages 93-103. The metallurgy of the crucible process and the production of tool steels in the coreless induction furnace are studied. While the first part has been treated before (See *Metals & Alloys,* Vol. 4, July 1933, page MA 220; Dec. 1933, page MA 392), the production of unalloyed tool steels with about 1% C was investigated under different kinds of slag after removing several times the slag which had accumulated ferrous oxide, and replacing it by raw glass; shortly before pouring the melt was deoxidized by ferromanganese and ferrosilicon, and also by reduction by the slag. The latter process in particular gave a very high quality of steel. The H content of the steel must not exceed a certain amount as otherwise the steel is not killed even after good deoxidation. By slowly heating or annealing for some time at red-heat of the materials added to the melt H content can be kept low. The testing of these steels and distribution of hardness are described. The best steel is obtained when the melting process is reducing in its early stages, under a slag poor in metal oxides and at sufficiently high temperature so that Mn and Si of the slag are reduced. 22 references. Ha (3b)

The Effect of Deoxidation on Some Properties of Steel. C. H. Herty, Jr. *American Society for Metals Preprint* No. 19, 1934, 9 pages. Discusses the effect of method of deoxidation upon the grain size, hardenability, aging, and impact characteristics of steel. Data presented showing impact strength of low C steel, vary from 2.0 to 110.0 ft. lb. at —40°F according to method of deoxidation of the steel. More complete deoxidation gives the higher impact strength. WLC (3b)

Influence of Time of Coking on the Properties of Coke for Melting Cast Iron (Der Einfluss der Garungszeit auf die Eigenschaften des Kokses und dessen Eignung für Giessereizwecke). E. Homborg. *Archiv für das Eisenhüttenwesen,* Vol. 8, Aug. 1934, pages 49-56. The effect of coking time and temperature on the structure of the coke is shown. By low temperature coking a structure can be obtained which has sufficient strength for high temperature melting as in a cupola. SE (3b)

Finishing the Heat of Steel. Pt. XXII. J. H. Hruska. *Blast Furnace & Steel Plant,* Vol. 22, July 1934, pages 395-397. Deals with piping and after-pouring to keep volume of piped section of ingot at a minimum. Use of a carbonaceous material to cover the molten metal added to the cavity is good practice. After-pouring should not be conducted too soon. Top crust should be of such thickness as to be easily remelted by the subsequently added steel. MS (3b)

Studies on the Equilibria of Iron and Oxygen with Silicon, Calcium, and Phosphorus (Untersuchungen über Gleichgewichte des Eisens und Sauerstoffs mit Silizium, Kalzium und Phosphor). F. Kanz, E. Scheil & E. H. Schulz. *Archiv für das Eisenhüttenwesen,* Vol. 8, Aug. 1934, pages 67-74. The Fe end of the systems Fe and O with Si, Ca, and P were studied by microscopic examination of the phases easily distinguishable at room temperature. The typical structures which appear are illustrated in 24 micrographs. A critical discussion of the various phases formed is given with many equilibrium diagrams. It is concluded that FeO, Fayalite $Fe_2\ SiO_4$, SiO_2, calcium-ortho-ferrite $2\ CaO \cdot Fe_2O_3$, CaO, and the phosphate $Fe_2P_2O_7$ may appear as inclusions in steel. SE (3b)

The Phenomenon of Inverse Chill in Cast Iron and Its Theories (Le Phénomène de Trempe inverse dans la Fonte et ses Théories). G. Dubercet. *Revue de Fonderie Moderne,* Vol. 28, May 25, 1934, pages 152-154; June 10, 1934, pages 166-168. Inverse or internal hardening is a not very frequent phenomenon; it is characterized by an appearance of the fracture of the pig, after the first melt or after remelting, which is gray at the edges while it is entirely white in the center beginning at a certain distance from the edges; both zones have all the properties of gray and white cast iron, in particular the inner white part has the usual hardness of white cast iron while the border zone has only the moderate hardness of gray iron. The white zone never reaches the edges and is always surrounded by gray iron with quite distinct demarcation. Various theories propounded by C. Howell Kain and L. F. C. Girardet are discussed but do not give a satisfactory explanation. Overheating does not account for the phenomenon. Also the assumption of an influence of the mold or of pressure exerted by the exterior layers as expressed by Norbury does not explain it fully. Ha (3b)

Grain Size Control of Open-Hearth Carbon Steels. S. Epstein, J. H. Nead & T. S. Washburn. *American Society for Metals Preprint* No. 14, 1934, 32 pages. Study of grain size control of open-hearth steel shows that with good furnace practice positive production of coarse or fine grained C steel at will can be obtained by controlled ladle addition of Al and controlled reactive O_2 content which depends on C, Mn, and Si in the steel. To produce intermediate grain size it is necessary to use higher Mn and/or Si content or making a low alloy steel. Microscopic inclusion counts and oxide analyses indicate that the amounts of Al required to give fine grained steel do not increase the number of large inclusions or affect cleanness of steel with either ladle or mold additions. Al and Si required for a fine grained steel results in fully killed deep piping steel requiring hot-topped molds and greater discard with higher cost. Tests indicate that fine grained steels have higher yield strength, slightly higher ductility, and higher impact resistance with tensile strength about equal to that of coarse grained steels. Hardenability of fine grained steels is distinctly lower than coarse but after carburizing uniform hardening of fine grain steels may be obtained by brine quenching. WLC (3b)

Molding Stainless Steel Pelton Bucket Castings. H. V. Fell. *Iron & Steel Industry,* Vol. 7, Oct. 1933, pages 3-5. Methods and suggestions are given for pattern making, molding, core making, pouring and finishing of steel bucket castings for Pelton turbines. CEJ (3b)

Making Quality Steels. Emil Gathmann. *Blast Furnace and Steel Plant,* Vol. 22, July 1934, page 401. Life of big-end-up molds can be extended by opening ladle stopper only partially until a pool of molten steel 5-7 in. deep is formed in the bottom of the mold chamber, and by centering ladle nozzle over vertical axis of the mold. MS (3b)

Production of Alloy Steel Castings. A. W. Gregg. *Transactions, American Foundrymen's Association,* Vol. 5, June 1934, pages 56-66. The production of alloy steel castings in the United States has risen steadily since 1918. Advantages of alloy steel castings, e.g. increased strength and increased heat and corrosion resistance have widened the field of application of castings. Procedures for manufacture and precautions that must be taken to produce them successfully are given. In the production of pearlitic and sorbitic classes of alloy castings alloying elements such as Ni, Cr, Mo, V, and Mn are added to increase strength for a given ductility, to increase ductility for a given strength, to increase resistance to wear and abrasion or to increase toughness to withstand shock. A representative list of 15 alloy steels which are taken from regular U. S. practice is given. In general the melting procedure for the production of alloy cast steels in the electric furnace is described emphasizing the need for control especially in the heat treatment operations. Care must be exercised in the production of pattern equipment and in the molding and coremaking operations due to the variations in shrinkage. Procedures for the removal of heads and risers from alloy steel castings are outlined. The value of a trained personnel and a research department receives comment. CEJ (3b)

WORKING OF METALS & ALLOYS (4)

Rolling (4a)

RICHARD RIMBACH, SECTION EDITOR

Rolling and Finishing Sheets. V. M. Harchenko. Gosudarstvennoe Naouchno-Technicheskoe Izdatelstvo, Moscow 1933. Paper, 6 x 9 inches, 88 pages. Price 1.50 rouble. Some information is better than none, and where there is a lack of adequately abundant and easily available literature the booklet by Harchenko would be of a considerable value. Under any conditions he deserves credit for gathering in one book much data scattered in the literature related to rolling of quality sheets. It is a compilation of published data, the subject of quality sheet rolling being new in Russia. However, the sources available to the author did not cover the whole field and in some occasions the papers consulted presented a somewhat distorted picture exaggerating the importance of some features or apparatus and forgetting others. In the description of rolling mills are omitted the installations in which the strip is drawn through the rolls as in the Steckel and similar mills. Kathner normalizing furnace is held as the only and the best, while no references to continuous, tunnel and other types of furnaces embodying a definite temperature cycle can be found. Some of the statements disagree with the generally accepted ideas, like five heat life of the soaking pit bottoms, 1600°F box annealing for low carbon sheets, addition of inhibitors in the amounts equal to 0.5% of the weight of the sulphuric acid, use of copper as in agriculture, etc. Were it more comprehensive, particularly from the production standpoint, it would be welcome to many rolling men. (4a) -B-

Progress in Tube Rolling Mill Construction. *Iron & Coal Trades Review,* Vol. 128, June 29, 1934, page 1049. The progress made in recent years in rolling seamless tubes and machinery for it is briefly reviewed, piercing and Pilger mills being the principal methods. A tube of 33 ft. length, 59″ diam. and 0.6″ wall thickness, requiring a bloom of about 6 tons is about the limit for these methods; a more recent development is described which permits making thicker walls for tubes up to 33 ft. length which can be used as boiler drums. Ha (4a)

Rails Cooled by Retarded Process. Frank Bohr. *Steel,* Vol. 94, Apr. 2, 1934, pages 44-45. From a report made public by the U. S. Department of Commerce. Describes process of Dominion Iron & Steel Co., Sydney, Nova Scotia, to prevent shatter cracks. When temperature of rails has been reduced to 750° F., they are transferred to specially constructed sheet steel tanks, with close-fitting lids to prevent escape of heat, where rails are allowed to cool to 100°F. No artificial means of cooling is used. Time required is about 72 hrs. MS (4a)

The Manufacture of Seamless Tubes. Gilbert Evans. *Engineering,* Vol. 137, Jan. 12, 1934, pages 30-32; Jan. 26, 1934, pages 87-88; Feb. 9, 1934, pages 137-138. Gives description of various manufacturing methods from the point of view of the operator. The following are dealt with: the Mannesmann process of rotary piercing of solid billets, the Stiefel disc-piercing apparatus, the Erhardt piercing press and push bench process, Evans' rotary reducing mill, the Diescher rotary method of rolling tubes from pierced billets, the automatic or plug mill, centrifugal-cast hollows for tube manufacture, tube-making from shells made by diffusion of molten metal, application of rotary piercing of billets in the non-ferrous tube trade. LFM (4a)

Rolling Mill Practice. Alfred F. Dixon. *Iron & Steel Industry,* Vol. 7, Jan. 1934, pages 139-143. General construction of various rolling mill installations is described. CEJ (4a)

Roughing Blooming Mill Rolls (Das Schärfen der Kaliberflächen bei Block-und Vorwalzen). C. Holzweiler. *Stahl und Eisen,* Vol. 54, Aug. 16, 1934, pages 853-854. Directions are given for grinding the corrugations in the rolls so as to avoid rolling in slivers. SE (4a)

Deformation Resistance when Rolling Steel in Passes (Ueber den Formänderungswiderstand beim Walzen von Stahl in Kalibern). E. Siebel & W. Lueg. *Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung, Düsseldorf,* Vol. 16, No. 9, 1934, pages 105-112. Deformation resistance, i.e., the force per unit of deformed surface which has to be applied for plastic deformation of the piece to be worked, was determined under practical conditions in a 3-high finishing mill as a function of the ratio: finished height of work (beams) to diameter of rolls. The resistance decreases with increasing ratio; it is given in curves and tables which must be referred to. 8 references. Ha (4a)

Factors to be Considered in Calculations on Rolling (Ueber Bezugsgrössen zur Berechnung der Hauptvorgänge beim Walzen). H. Hoff & T. Dahl. *Stahl und Eisen,* Vol. 54, June 21, 1934, pages 655-662. After extended calculations formulae are derived for the work in rolling and power in starting. SE (4a)

Flood Lubricated Bearings. W. Trinks. *Blast Furnace & Steel Plant,* Vol. 22, June 1934, page 343; July 1934, page 403. Flood lubricated bearings for roll necks call for good design and the best of workmanship. Journal surfaces must be ground with extreme care and should rightly be hardened and ground. Bearing shell must be ground and strong enough to resist deflection relative to its support. Length of neck should be less than its diam. Oil must be perfectly clean and rapid circulation of oil through the bearing must be provided. High-speed mills are particularly well adapted to being equipped with this type of bearing. MS (4a)

New Viewpoints on the Maintenance of Rolling Mill Bearings (Neue Gesichtspunkte zur Pflege der Walzwerkslager). Erich Kadmer. *Motorenbetrieb & Maschinenschmierung, supplement to Petroleum,* Vol. 29, July 7, 1933, pages 2-6. Rolling mill friction bearings of 250-1000 at. average bearing pressure yield satisfactory service under semi-liquid, semi-dry and dry friction. Under these service conditions, bearing metals high in Sn (about 87% Sn) are superior to Pb-bearing white metals. Above 300 at. cast bronze 10 is superior to red brass. The friction coefficient of the former however does not drop below 7-10% whereas Sn 87 yields 5-7% at 100 at. and 1-2% at 500 at. pressure. Consequently Sn 87 shows the lowest temperature rise in service. Pure mineral oil is unsuitable as lubricant, colza oil of the same viscosity (3-4 Engler units at 50°C.) is well suited. 10% additions of colza oil to distilled mineral oil render the latter serviceable. Colloidal graphite additions of 1-2% protect the bearings against seizing even at elevated temperatures. High melting point fats which contain graphite additions can be employed for high pressure lubrication. (150 at.) Roller bearings cut down energy consumption but only last about 6 months in the case of bearing pressures of 9 tons max. EF (4a)

Pressure Lubricated Frame Bushings for Rolling Mills (Das Rahmenlager mit Druckschmierung für Walzwerke). H. Weinlig. *Stahl und Eisen,* Vol. 54, Aug. 2 1934, pages 801-806. The makeup of the frame bearings by the insertion of smaller bearings is illustrated, as well as the means of pressure lubrication. There frame bearings lowered operating costs and power consumption as compared with cast red brass bearings. SE (4a)

Developments in the Construction of Rod Mills (Entwicklungen im Bau von Drahtwalzwerken). H. Kalpers. *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, June 3, 1934, pages 338-341. Points of general interest to be observed in rolling steel rod are first considered. Several types of modern German mills are described with special reference to (1) a semi-continuous rod mill made by Quast, Rodenkirchen near Cologne as installed at a French mill, (2) a continuous rod mill of Demag, Duisburg as installed at Niederrheinische Hütte, Duisburg. (3) a second type of a semi-continuous rod mill, type Quast. Finally a controlling outfit, system Reinecke, for making truly round rods is described. GN (4a)

Forging & Extruding (4b)

A. W. DEMMLER, SECTION EDITOR

Liquation Observed in Large Steel Forgings. S. A. KAZEEV. *Transactions of the Leningrad Institute of Metals* (*Soobschenia Leningradskago Instituta Metallov*), No. 13, 1933, pages 34-40. In Russian. An interesting case of liquidation of sulphur was observed in forging large rotors for electric generators from steel ingots weighing up to 30 tons. The steel sampled from the rotors had compositions of 0.36-0.43% C; 0.20-0.23% Si; 0.64-0.66% Mn; 0.006-0.012% S; 0.026-0.035% P with additions to one melt of 0.1% Cr; 0.47% Ni; and 0.26% V. A large number of forgings were rejected because of low values of elongation and reduction of area. An examination of the structure of rings cut from the rotors revealed a pronounced non-uniformity in distribution of sulphur throughout the forging. The sulphur inclusions were present in the form of "heaps" surrounded by zones low in carbon. The sulphide inclusions were of two types: (1) Single large inclusions and (2) segregations consisting of number of small inclusions. It appeared that the large inclusions were made of sulphides which were formed when the steel was in a liquid state whereas the small inclusions were result of chemical reaction that took place during solidification of the ingot due to concentration of manganese and sulphur in the interdendritic spaces during crystallization. Non-uniformity of distribution of carbon was evidently due to segregation of phosphorus. That the inferior mechanical properties of the steel was caused by segregation of sulphur was proved by comparison of the data obtained with the specimens taken from the central portion of forging showing segregation of sulphur and specimens taken from the zone near to the periphery of forging showing no segregation. AIK (4b)

Forging and Rolling Wide Range of Alloy Steels. J. B. NEALEY. *Steel,* Vol. 95, July 16, 1934, pages 43-44, 46. Describes plant and procedure of the Latrobe Electric Steel Co., Latrobe, Pa., for the production of more than 150 separate alloy steels. Equipment includes 4 melting furnaces; steam hammers; 5 mills ranging from 9 to 16 in. for hot rolling; draw-benches and mills for cold working; and furnaces for heating, annealing, hardening, etc. MS (4b)

Further Experiments on the Forgeability of Steel. O. W. ELLIS. *Transactions American Society for Steel Treating*, Vol. 21, Aug. 1933, pages 673-707. Measure of forgeability used for this study was % reduction of specimen 1" high and 1" diam. under blow of 520 ft.-lb. Forgeability-temperature curves are given for C steels, 0.10, 0.16, 0.68, & 0.85% C, S.A.E. 2320, 2345, 3120, 3135, 3245, 5130 & 6120. Results indicate that addition of Ni, Cr, or both to low C steel has little effect from forgeabiliay. In medium C steel addition of these elements appears to reduce the forgeability. No relation could be established between melting practice and forgeability on C steel, C 0.85-0.90. C has a much greater effect upon forgeability than any of the other elements studied. WLC (4b)

The Effect of McQuaid-Ehn Grain Size on Steel in Forging. W. E. SANDERS. *American Society for Metals Preprint* No. 17, 1934, 17 pages. Describes development of denser forgings free from slipping and tearing of fibers by employing steel of specified grain size and structure, accurate forging temperatures and specially designed dies to control the flash and insure greater compression of the forging. Evidence presented indicates that manner of hot working affects the density of grain boundary material, the effect of work being concentrated in grain boundaries; thus forgings of large grain size are preferable because there will be less density changes in the few grain boundaries. Controlled forging process has as its object as little disruption of the grain boundaries as possible and such control and selection of steel result in increased machinability. WLC (4b)

Forging Plant and Practice. F. APPLEYARD. *Iron & Steel Industry,* Vol. 7, Jan. 1934, pages 135-138, 143. Presses up to 15,000 tons power have been installed. Comparisons are made between the following types of prime movers: steam-hydraulic intensifier, air-hydraulic intensifier, electrically operated intensifier, hydraulic accumulator and a direct pump. The most prevalent, the steam-hydraulic intensifier system offers high speed of working, ease and simplicity of operation, low maintenance costs and is generally efficient. Presses for special purposes and also mechanical manipulators are discussed. CEJ (4b)

Drop Forging at the Fair. *Heat Treating & Forging,* Vol. 20, July 1934, pages 337-338, 343. **4000-Pound Drop Hammer Installed at Fair To Forge Steering Knuckles.** *Steel,* Vol. 95, July 30, 1934, pages 34, 36. Describes forging procedure and hammer installed in the exhibit of the Chrysler Corporation at the Century of Progress. MS (4b)

Drums of Heavy Hollow Forgings. EDWIN F. CONE. *Heat Treating & Forging,* Vol. 20, July 1934, pages 323-325. Describes manufacture of such forgings by the Bethlehem Steel Co. and discusses some of their advantageous properties and their applications. MS (4b)

Drawing & Stamping (4c)

Effect of Cold Work on the Microstructure of Low Carbon Steel Tubes. E. P. POLUSHKIN. *Transactions American Society for Metals,* Vol. 22, July 1934, pages 635-656. The effect of cold working tubes by 3 different processes is described, (1) ordinary bench drawing, (2) Dudzeele process in which electro-deposited lead on interior surface provides lubrication and (3) Rockrite process which effects working by compressive forces exerted by oscillating semi-circular dies. Low carbon steel tubes may be reduced 50 times by Rockrite process 6.5 times by Dudzeele and 1.5 times by ordinary bench drawing process. This striking difference is explained by absence of slip lines in the Rockrite tubes. Compressive stresses of Rockrite process produce longitudinal deformation lines instead of the slip lines of the tensional stresses of the drawing processes. Study of dimensional changes of grains of these tubes showed that grains do not lengthen more than 2.5 times after which further work results in fragmentation. Recrystallization of grains took place at lower temperatures in Dudzeele tubes than in Rockrite tubes because the separation of new grains was facilitated by presence of slip lines. WLC (4c)

Why Pay Double Freight on Scrap. W. TRINKS. *Blast Furnace & Steel Plant,* Vol. 22, July 1934, page 403. Advocates blanking of sheets and strip at the rolling-mill instead of at the ultimate manufacturing plant. MS (4c)

Dowel-Pins and Their Use in Diemaking. L. PICKETT. *Machinery,* N. Y., Vol. 40, June 1934, pages 582-584. Practical points on determining size, material, finish and fit allowance are discussed. Ha (4c)

The Effect of Cold Working on the Physical Properties of Cold-Headed Bolts. C. L. HARVEY. *Transactions, American Society for Metals,* Vol. 22, July, 1934, pages 657-672. Cold headed bolts of more than 0.30% C or of alloy content may be completely relieved by heat treatment and a method of relieving the cold work effects in the headed section of less than 0.30% C bolts without sacrifice of physical properties imparted to the shank by cold work. The process is commercially practical and produces an excellent bolt free from danger of head failures. Discussion. WLC (4c)

The Importance of Grain Size of Sheet Steel for Deep Drawing. REID L. KENYON. *American Society for Metals,* Preprint No. 12, 1934, 17 pages. Grain size is only one of several important variables which affect the deep drawing quality of sheets but it has a profound influence on the drawing quality and surface finish when box-annealed and normalized sheets are used. Fine grained material is somewhat harder but more ductile and gives a smoother surface after severe deformation. Commercial normalized sheets show narrow variation in grain size and the range best suited for specific jobs is determined by experience. Experience in producing sheets for deep drawing show that physical test data and grain size indicate the drawing quality and their control will produce material suitable for present day requirements. It is assumed that appropriate composition and thermal and mechanical treatment are known and are controlled in production. WLC (4c)

Cold Heading. CARL L. HARVEY. *Steel,* Vol. 94, Jan. 29, 1934, pages 23-26. From paper read before the Cleveland Chapter, American Society for Metals. Discusses tool and die problems. Sintered carbide dies for wire drawing should have throat truly conical in shape, and junction line between throat and bearing should be broken only to a very small extent. Entrance angle of 20°-22° and bearing length of 60-70% give good results. Dies should be polished at regular intervals. Difficulties encountered in cold heading, usually in connection with solid die machines, can be traced to improper set-up, defective wire, or bad tools. Solid-header dies are usually made of straight-C steel with 1% C and 0.20-0.30% Mn, hardened from 1525°-1550° F., and drawn back to a Rockwell hardness of C58-60. Increased rate of cooling attained when quenching from the higher temperatures results in increased die life. Proper quenching is accomplished by forcing coolant through die at 10-25 lbs. pressure. For trimming dies, 18-4-1 high-speed steel and high-C high-Cr steel are most satisfactory. High-speed steel hardened at 2250°F. and drawn to Rockwell C60 gives excellent results. Thread rolling dies are made of straight-C, H_2O-hardening steel; low-alloy, oil-hardening steel; high-C high-Cr oil or air-hardening steel; and high-speed steel. Long, slow heating in a neutral atmosphere is necessary in hardening these dies. In the case of the last 2 steels, satisfactory results have been obtained, when using as a packing medium, gas-coke which had previously been heated to a temperature slightly above the hardening temperature. MS (4c)

Influence of Carbon Content and Heat-Treatment on Drawability of Steel Wire (Einfluss des Kohlenstoffgehalts und der Wärmebehandlung auf die Ziehbarkeit von Stahldraht). ANTON POMP. *Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung, Düsseldorf.* Vol. 16, No. 10, 1934, pages 113-116. 5 steel wires with from 0.35-0.77% C were investigated under definite conditions of heat-treatment with respect to change of deformation resistance with degree of deformation. The drawability of the wires appeared to be practically independent of furnace temperature. The deformation resistance increases with increasing C content for all reductions and also with increasing deformation while furnace temperature and temperature of a subsequent tempering bath has only slight influence. Ha (4c)

Drawing and Polishing Stainless Steel. R. F. JOHNSTON. *Machinery,* N. Y. Vol. 40, June 1934, pages 589-590. For drawing stainless steels heavy lubricants are necessary as the material is so dense that when drawn the lubricant may be squeezed completely from the sheet and the latter "freeze" to the die. For polishing, aluminum oxide of No. 80, 100 and 120 is used in succession, with a tallow grease as lubricant in the last operation. Care must be taken not to let the material get too hot in polishing as the heat conductivity is much less than in ordinary steels. Compositions of pickling solutions are given. Ha (4c)

Lubricants for Metal Working. *Chemical Trade Journal & Chemical Engineer,* Vol. 93, Sept. 22, 1933, page 211. A short discussion of the advantages and disadvantages of the various ingredients commonly used in making up lubricating mixtures for metal working processes. JN (4c)

Plate-Flattening Machine with Automatic Pressure-Grease Lubrication. *Iron & Coal Trades Review,* Vol. 128, June 1, 1934, page 887. The machine can flatten cold steel plates from 0.11 to 0.25 in. thickness and up to a width of 6 ft. It has 9 rollers with supporting rollers, each separately adjustable. Ha (4c)

Developing Blanks for Bending and Forming. C. W. HINMAN. *American Machinist,* Vol. 78, July 18, 1934, pages 507-508. Blank developments and formulae for calculating dimensions are given. Ha (4c)

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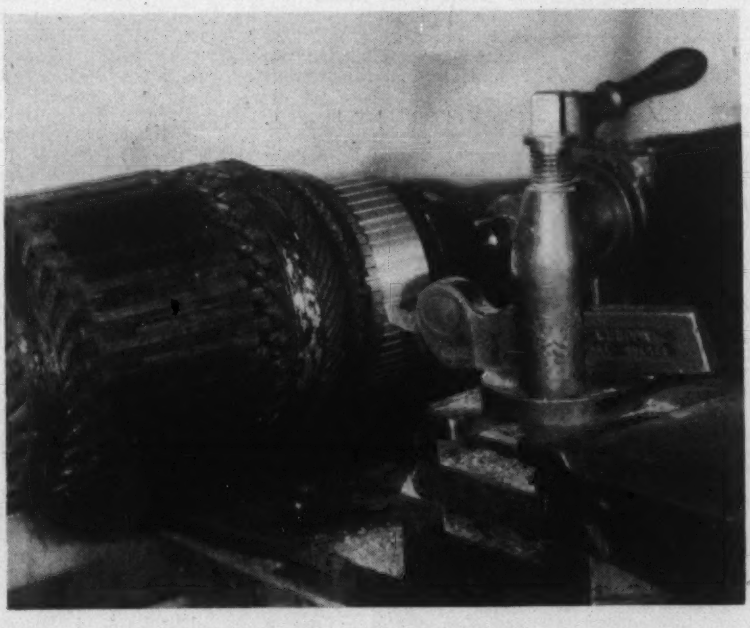

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Machining (4d)

H. W. GRAHAM, SECTION EDITOR

Grain-Size in Relation to Machinability and Other Properties of Bessemer Screw Steel. H. W. Graham. *American Society for Metals Preprint* No. 10, 1934, 15 pages. Presents data on 14 lots of Bessemer screw stock representing the product of 4 different plants. Machinability measured by tool life in minutes is compared to chemical and physical properties and grain size as received and after McQuaid-Ehn Test. No clear relation exists in any case but it appears that machinability is improved by greater grain size. A work-brittleness test is described and its application as a criterion of machinability discussed. Curves of tool life against surface speed of machining show that the relative machining quality of various lots of steel is largely independent of speed. Lower Izod is associated with good machining properties and great loss of impact resistance in the work-brittleness test indicates good machinability. High impact strength indicates a toughness that results in a dissipation of stresses in a large volume of steel around the point of the tool and increased difficulty of cutting while low impact strength has the reverse meaning. The probability of greater resistance to cutting at the grain boundaries than in the grains is discussed. The relative energy required to rupture through a grain as compared to that required to cross a boundary must be known to evaluate properly the relation between grain size and machinability. WLC (4d)

Drilling Manganese Steel. H. Bentley. *Iron & Steel Industry,* Vol. 7, Dec. 1933, page 73. Machine powerful enough to cut continuously is necessary to overcome work hardening. Peripheral cutting speed of 14 to 15 ft. per minute with automatic feed ranging from 0.004" to 0.006" per revolution of machine spindle are satisfactory. Drilling facilitated by slightly warming work and drill by a blow flame. No lubricant should be used. CEJ (4d)

The Life of Turning Tools as Influenced by Shape. O. W. Boston & W. W. Gilbert. *Transactions American Society for Metals,* Vol. 22, June 1934, pages 547-576. The relation between the cutting speed and tool life for a given tool when cutting a given steel under constant conditions has long been known to follow the equation $VT^n = C$. This relation has been shown at different times to hold for tools of different compositions when cutting a steel, and tools of a constant type when cutting various steels. There is a wide range in value of exponent and constant, however, as factors such as tool material and shape, material being cut, size and shape of cut, etc., are varied. The relative importance of these factors has not been clearly defined. This paper gives the results of an investigation to determine the value of the exponents and constants of the tool-life cutting-speed equation, $VT^n = C$, for a given tool of high speed steel when cutting an S. A. E. 2335 steel forging. All tests were run dry and the data submitted are from cuts 0.100" in depth and 0.0125" feed per revolution. The variables studied were the tool-nose radius, the side-cutting angle, the side rake angle, and the back rake angle. It is shown that there is a definite relation between each of these variables and the exponent and constant of the equation. WLC (4d)

Cutting Temperatures Developed by Single Point Turning Tools. O. W. Boston & W. W. Gilbert. *American Society for Metals Preprint* No. 5, 1934, 21 pages. Investigation of the tool temperatures in cutting a plain steel, 0.61% C with commercial 18-4-1 type of high speed tool. Temperatures were determined from the thermal emf. between the tool material and work with appropriate insulation. Effects of nose radius, side-cutting angle, back-rake angle, feed and depth of cut upon the temperature are given in empirical equations. Increase in temperature with increasing speed is more rapid up to 550° F. than above where it is nearly proportional to increase in speed. Increase in nose radius from 0 to 1/4" permits a 68.8% increase in speed at any constant temperature. Surface color of chip is not a direct indication of tool temperature. Increasing side-cutting angle from 0 to 60° permits increasing speed 71% at constant temperature. Increasing side-rake angle from 0 to 40° makes possible an increase in speed of 61.7% without effect upon tool temperature. Back-rake angle has little effect upon tool temperature. At constant operating speed minimum tool temperature is obtained by using large depths and small feeds for a given area of cut. 8 references. WLC (4d)

Machining Operations on Pipe Wrench Components. C. A. Bucknell. *Machinery,* London, Vol. 44, Apr. 26, 1934, pages 92-94. Deals with the various stages in the production of pipe wrenches and machine tools employed. Discussion of heat-treatment. Kz (4d)

New Type Cutting Tools Demand Less Vibration in Machines. Everett Chapman. *Machinery,* N. Y., Vol. 40, July 1934, page 671. Cemented-carbide cutting tools, due to their structural characteristics, require a particularly solid mounting with as little vibration as possible. The finely divided carbide particles break up the structure of the matrix which, though in itself it possesses good physical strength is weakened by it. Construction of a lathe for such purpose is described. Ha (4d)

Machining Heavy Crankshafts. *Machinery,* London, Vol. 44, Apr. 5, 1934, pages 1-6. Discussing the practice of the English Steel Corporation, Ltd., Sheffield, among others the production of 5-throw Diesel engine crankshafts are dealt with. The crankshafts had to be produced without twisting the forging to form the crank-throws. Forgings were used in which the journal and intermediate bearings were necked down, the metal between the bearings being swaged to the approximate angular position for the respective crank-throws. Crank-throws and crank-pins were then cut out of the solid metal. Material used was a 0.4% C steel. Kz (4d)

Progress in Fine Machining (Fortschritte in der Feinstbearbeitung) *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, May 20, 1934, pages 300-306. After outlining the field of various fine machining methods as (1) lapping and honing, (2) fine grinding, (3) working with hard metal tools, paper considers in particular methods under (3). Turning lathes and drilling machines applying either hard metal tools or diamonds are described in detail. GN (4d)

Performance of Cutting Fluids When Sawing Metals. Progress Report No. 5 of the Subcommittee on Cutting Fluids of the A. S. M. E. Special Research Committee on the Cutting of Metals, prepared by O. W. Boston & C. E. Kraus. Presented at annual meeting of American Society of Mechanical Engineers, New York, Dec. 4-9, 1933. *Transactions A. S. M. E.,* Vol. 56, No. 7, July 1934, pages 527-531. Presents results of two series of tests conducted on a Peerless high-speed 9" capacity power hacksaw at University of Michigan. First series was to determine influence of 4 typical cutting fluids on wear of teeth of tungsten-steel hacksaw blades when cutting a Bessemer screw-stock steel. Second series was to determine influence on cutting time of 11 cutting fluids when sawing each of 8 different metals with high-speed-steel blades. It appears that cutting fluids appreciably affect rate of dulling of tungsten-steel hacksaw blades and time necessary to cut a given cross-section when operating under a given feed pressure. A cutting fluid giving a short sawing time with a sharp blade, however, does not necessarily give relatively short times after the blade becomes dull. It was found that the sulphurized oils were best because of the shorter sawing times and the least wear on the saw blades. The 1 to 50 emulsion was found to be better than a straight mineral or a mineral-lard oil. (Materials and cutting fluids are described in paper RR-55-1, American Society Mechanical Engineers, *Transactions A. S. M. E.,* Vol. 55, Sept. 30, 1933, pages 1-29.) See also *Metals & Alloys,* Vol. 5, July 1934, page MA 324. MFB (4d)

HEAT TREATMENT (5)

O. E. HARDER, SECTION EDITOR

The P-F Characteristic of Steel. B. F. Shepherd. *American Society for Metals,* Preprint No. 31, 1934, 23 pages; **Tool Steels are Classified by New P-F Characteristics.** *Steel,* Vol. 94, May 14, 1934, pages 43-44. Describes test pieces and method of grading tool steels according to the penetration of hardness and the fractures at four temperatures, 1450°, 1500°, 1550° and 1600° F. The characteristic of steel is given in 8 numbers, first four indicating penetration in 64ths of in. and second four the fracture grain size, the first of the four numbers being penetration or fracture grain at 1450° and higher temperatures in order. P-F characteristic reads as 5.6.8.12/9.8.6.4. The numbers are read to nearest 1/4. P-F characteristic is a heat property and is due to melting and not casting practice as surveys of heats show, though a test on first and last ingots is necessary to assure uniformity in the heat. Steels are divided into three types according to following

Type	P	F
1.	3/64 in. or less change	Not more than one number
2.	More than 3/64 in. but does not harden through	More than one number less than two numbers
3.	Hardens through at 1600° F.	More than 1¾ number change

Segregation influences hardenability as shown by dumbbell shaped core in flat hardened slabs showing a center condition which increases penetration, this is a heat characteristic. Prehardening structures have an effect upon P-F charaeteristic particularly with Type 3 steels though Type 1 is rather insensitive to changes between pearlitic and sorbitic structure. Oil quenching from 1600° F. is used to produce uniform prehardening structure. Modified P-F test for carburizing grades is described. WLC + MS (5)

Salt Baths for Dural. F. H. Trembly, Jr. *American Machinist,* Vol. 78, July 18, 1934, page 497. Airplane parts of duralumin are heat-treated in baths of molten salt which are heated by gas. Temperature control is described. Ha (5)

Annealing (5a)

Bright Annealing of Steel in Mixed Gas Atmospheres. A. L. Marshall. *Transactions American Society for Metals,* Vol. 22, July 1934, pages 605-624. Paper read before A.S.M. convention Oct. 1933, Detroit. Complex gas mixtures of CO, CO_2, H_2, and H_2O will etch low carbon steel at 650° C. (1200° F.) unless composition is held within certain limits. Producer gas and water gas reactions are responsible for this action. Low carbon steel may be annealed without oxidation in hydrogen containing 20% H_2O. Ratios of CO to CO_2 which produce etching and the effect of H_2 upon this action are discussed. Gas mixtures obtained from incomplete combustion of city gas are suitable for bright annealing when moisture is properly controlled. Ethylene and O_2 must be completely removed. Commercial installation for production of such bright annealing atmosphere is described and table gives gas compositions. Discussion. WLC (5a)

Hardening, Quenching & Drawing (5b)

Salt Bath Quenching. Bernard Thomas. *Heat Treating & Forging,* Vol. 20, June 1934, pages 285-287, 290. Investigation of effect of temperature of salt bath and of mass of article being quenched on hardness. Tests were carried out with strips of acid open-hearth steel containing 0.69% C. in a mixture of alkaline nitrates and nitrites. Found that for same thckness of metal, risk of obtaining quench cracks and tendency towards brittleness decrease with rising temperature of quenching bath. Increasing the mass of metal reduces quench cracks to a minimum. For obtaining complete penetration or uniformity of hardness, 3/16" is maximum thickness permissible. MS (5b)

The Problem of Quenching Media for the Hardening of Steel. Howard Scott. *Transactions American Society for Metals,* Vol. 22, July 1934, pages 577-604. Paper read before Heat Transfer Symposium, A.S.M.E. and A.S.M., Dec. 5, 1933, New York. Cooling of metals from a red heat to room temperature in a liquid proceeds in three stages, (1) transfer of heat to a vapor film surrounding the metal at the high temperatures, (2) most active heat removal occurs at temperatures at which vapor film is not maintained but heat is removed by mechanical action of boiling, (3) removal of heat by convection through the liquid. First stage is most pronounced in liquids having a sharp or low boiling point and can be suppressed in water by rapid agitation or certain additions to the water as salt and sulphuric acid. Water and water solutions of inorganic compounds are markedly more efficient in the second stage and give very high coefficients of heat removal. Quenching oils are less active in this stage but the first inefficient stage is almost entirely absent. Shallow penetration of hardening in plain carbon steel minimizes distortion and is most effectively obtained by highest rate of cooling obtainable as in submerged water spray on symmetrical shapes. Concentrated sulphuric acid is most satisfactory for unsymmetrical shapes though some hazard is attached to its use. Alloy steels of deeper hardening character are best hardened in oil which provides a satisfactorily rapid cooling at high temperatures. Oils cool slowly at low surface temperatures reducing distortion and danger of cracking. 15 references. Discussion. WLC (5b)

Rail Ends "Sorbitized" in Track To Prevent Batter. H. E. Morse, R. E. Frickey & A. S. Kalenborn. *Steel,* Vol. 94, Jan. 22, 1934, pages 27-28. Abstract of paper read before the Golden Gate Chapter, American Society for Steel Treating. Describes the Teleweld process, utilizing portable equipment. Rail ends are preheated to 600° F., by an induction-type heater, after which they are heated to 1600° F. in 2 min. by an automatic electric arc. Quenching is accomplished by a separate unit, with which oil is circulated at a fixed temperature and for a predetermined time. Rail is air cooled to atmospheric temperature, drawing being done with the residual heat under an asbestos blanket. MS (5b)

On the Cause of the Brittleness of Silchrome Steel. Seiji Nishigori. *Tetsu to Hagane,* Vol. 20, Feb. 25, 1934, pages 91-99. (In Japanese.) By the dilatometric measurement, microscopic observation and Rockwell hardness test, the critical points of two kinds of silchrome steels (0.406% C, 2.81% Si, 0.39% Mn, 12.89% Cr, 0.90% Mo and 0.451% C, 2.49% Si, 0.30% Mn, 12.68% Cr, 1.00% Mo) were determined. On heating the transformation proceeds between 970° (start) and 1070° C. (end). By tempering the specimens quenched from a temperature above 1000°, volume contraction occurs at 100°-150° due to change of α-Martensite → β-Martensite, expansion at 520°-570° due to Austenite → Martensite, and another contraction at 570°-650° due to Martensite → Sorbite. By measurement of the impact resistance after various heat treatments, and examination of the microstructure it was deduced that the cause of the brittleness is mainly due to the primary carbide segregated on the grain boundaries. The following heat treatments were proposed for preventing the brittlenses; (1) the steel is heated for 30 minutes at 1070°-1100° C. and quenched in oil. (2) heated again for the same length of time at 1000°-1030° and quenched in oil. (3) tempered for 30-60 minutes at 850° and cooled in air. TS (5b)

Materials of the Toolroom Hardening Shop. J. Knight. *Mechanical World & Engineering Record,* Vol. 95, Mar. 2, 1934, pages 199-200; Mar. 9, 1934, pages 229-230. The modern tendency in toolrooms is to substitute oil-hardening non-shrinking steels in place of the older type of water-hardening steel. Discussion of quality and characteristics essential for a good quenching oil. After critical discussion of methods in heat-treatment aiming at the insurance of uniformity of temperature throughout the piece to be treated, various salts used for hardening and tempering media are dealt with. Data on mixtures are given. Kz (5b)

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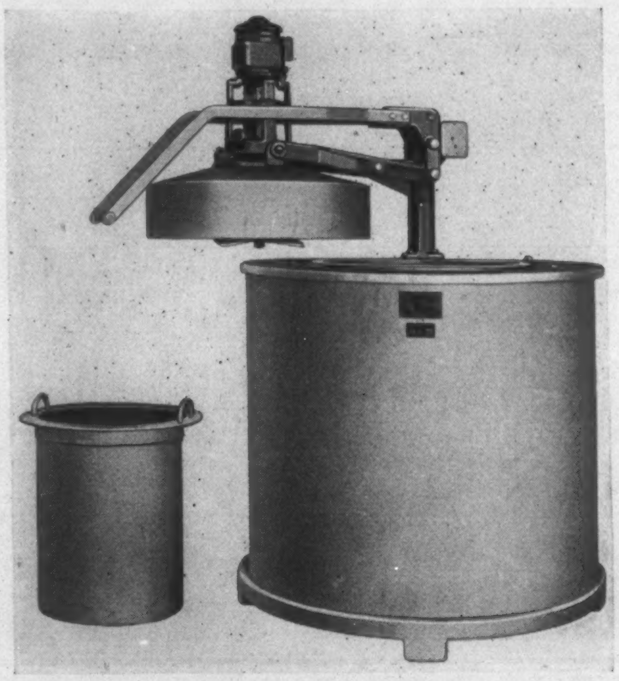

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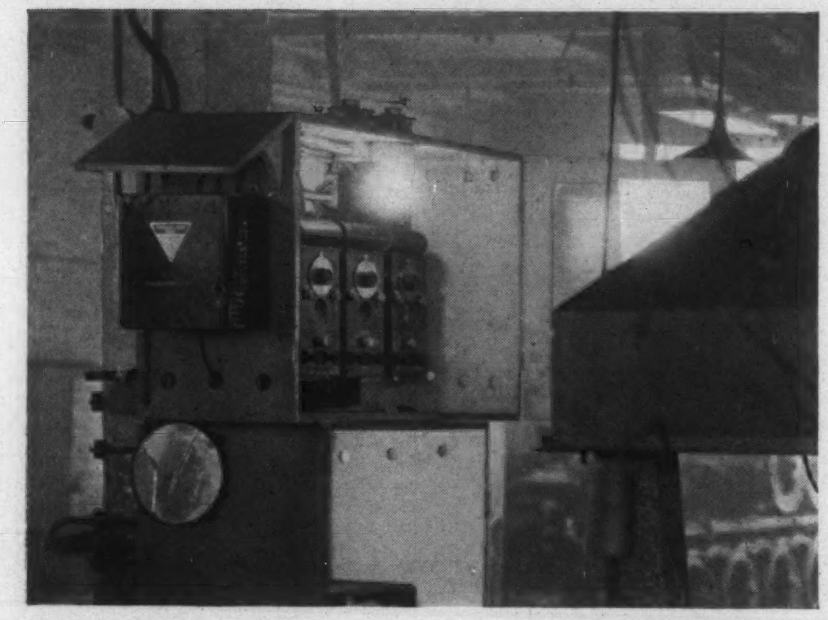

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Prolonged Tempering at 100°C. and Aging at Room Temperature of 0.8 Per cent Carbon Steel. G. A. Ellinger & R. L. Sanford. *American Society for Metals, Preprint* No. 8, 1934. 13 pages. Thermo-magnetic analysis is applied to the study of the effect of prolonged low temperature tempering and of aging for long times on hardened steel, 0.78% C. Data presented supports conclusions that martensite is unstable but tends toward stability upon application of heat or upon aging, liquid air cooling after quenching appreciably accelerates stabilization; retained austenite in hardened steel is not affected by tempering but decreases with aging; and rate of formation of cementite is not changed by tempering but its time is increased by aging. WLC (5b)

Developments in Fusion Technique (Neuerungen auf dem Gebiete der Autogentechnik). Ernst Greger. *Der Autogen Schweisser,* Vol. 7, Mar. 1934, pages 30-32. Deals with the surface hardening of steels containing 0.4-0.8% C. by means of the oxy-acetylene flame, showing an increase in hardness from 150 to 650 Brinell. Illustrated discussion of a surface hardening machine manufactured by the Autogenwerk "Griesheim," allowing the quenching of the heated portions by water, steam, or air blast immediately behind the watercooled burner. Hardness penetration: 2-3 mm., working speed: 10-12 cm./min. Movement of the burner is automatically controlled. Economy of the process and the various applications are pointed out. The increase in hardness (Brinell and Rockwell) is illustrated by means of diagrams plotted for steels containing 0.4-0.8% C. showing the surface hardness before and after heat treatment. Kz (5b)

Cooperative Studies by Oil-Users and Oil-Makers (Gemeinschaftsarbeit zwischen ölverbrauchender und ölverarbeitender Industrie) G. Baum. *Stahl und Eisen,* Vol. 54, Aug. 2, 1934, pages 797-801. Suitable lubricants for steam and diesel engines, rolling mills, and machining operations are briefly discussed. For oil quenching of steel a mineral oil seems to be preferred. A mineral oil which leaves a very clean surface after quenching is mentioned. SE (5b)

Aging (5c)

Age-hardening Alloys of Iron-Nickel-Aluminum-Copper (Aushärtbare Aluminium-Eisen-Nickel-Kupferlegierungen). E. Vaders. *Zeitschrift für Metallkunde,* Vol. 25, Nov. 1933, page 291. The solid solubility of Al in Fe-Ni alloys is much greater at temperatures of 800° and above than at temperatures between 450° and 700°. Soft alloys are obtained by heating at 900° from 1-3 hrs. and quenching. Only one solid solution may be observed in this state. Tempering between 450 and 700° produces precipitation and age-hardening. Cu-Ni-Al alloys may contain up to 20% Fe without harming the working qualities of the alloy; this Fe-content produces the most useful alloy because of the greater solid solubility of Al caused by the Fe. An alloy of 10% Ni, 4% Al, rest Cu, gave a tensile strength in the age-hardened state of 86.8 kg./mm.^{2}; an addition of 10% Fe gave 99.7 kg./mm.^{2} Fe also gave higher elongation values. Additions of Mn increase the elongation but decrease the degree of age-hardening, while Si exerts opposite effects. These alloys were also studied on a commercial scale; a combination of age-hardening and cold rolling gave a tensile strength value as high as 140 kg./mm.^{2}, an alongation of 2-3%, and a Brinell hardness number of 350. These alloys are therefore with Cu-Be alloys the strongest Cu-bearing alloys available; and are cheaper than Cu-Be alloys. The high mechanical strength, the corrosion resistance, and the resistance to oxidation at high temperatures of these alloys promises a wide application. RFM (5c)

Rate of Age-Hardening of Duralumin as Determined by Upsetting Tests. J. O. Lyst. *Metals & Alloys,* Vol. 5, Mar. 1934, pages 57-58. Specimens twice their diameter in length were loaded in compression and load reading taken after 25 and 50% shortening had taken place and the amount of deformation at first appearance of cracking noted. From the load readings an arbitrary workability factor is calculated. From the study using this method it was found that at room temperature appreciable age-hardening takes place in 1¾ hours, at 0° C. hardening does not become appreciable until 36 hours, at —48° C. hardening is suppressed for at least 14 days after which time it will act at a higher temperature as if it had just been quenched. WLC (5c)

Influence of Various Elements on Precipitation Effects in Steel on Tempering (Einfluss verschiedener Elemente auf die Ausscheidungsvorgänge im Stahl beim Anlassen. W. Eilender, A. Fry, & A. Gottwald. *Stahl und Eisen,* Vol. 54, May 31, 1934, pages 554-564. Vacuum melted pure Fe alloys were studied by means of electrical conductivity, magnetic, and hardness tests for precipitation effects after quenching and tempering. C, N_2 and Cu gave precipitation effects but O_2 by itself definitely did not although it may perhaps do so in combination with C_2 or N. Particle size was indicated to be most important. Steels with only O_2 gave no Fry etching strain figures such as appeared in steels with N_2. Precipitation effects in C steels were eliminated on adding Ti or Mo. SE (5c)

The Effect of High Hydrostatic Pressures on Aging. Leland Russell van Wert. *American Society for Metals Preprint* No. 1, 1934, 10 pages. Commercial duralumin, duralumin with 0.17% Ca, 1.0% Si, 0.6% Mg, 0.5% Fe-Al alloy, 10% Zn, 1% Cu, 0.7% Fe, 0.8% Si, 0.75% Mn, 0.4% Mg-Al alloy, 0.04% Ca-Pb alloy and 0.07% N-Fe alloy were studied for the effect of hydrostatic pressures upon rate of aging. Pressures of 12000 atm. were found to decrease the rate of aging in all but the Fe-N alloy where no detectable change in rate was observed. Final hardness is not affected. The decrease in rate of aging appears to be due to pressure's effect upon the viscosity of the metastable solid solution. WLC (5c)

The Influence of Heat-treatment and of Long Periods of aging upon the properties of an Aluminum Alloy (Der Einfluss der Wärmebehandlung beim Aushärten und der langdauernden Lagerung auf die Eigenschaften einer Aluminiumlegierung). W. Schwinning & E. Dorgerloh. *Zeitschrift für Metallkunde,* Vol. 26, Apr. 1934, pages 91-92. Data are given in the form of tables and graphs on the tensile and fatigue properties of an alloy of high electrical conductivity, quenched from temperatures of 460, 490, and 530°, and aged for eight hours at 120, 145, 160, and 175° and up to two years at room temperature. The composition is not stated. RFM (5c)

Aging and Tensile Strength at Elevated Temperatures of Cast Steel (Alterung und Warmzugfestigkeit von Stahlguss). E. Knipp. *Stahl und Eisen,* Vol. 54, July 26, 1934, pages 777-778. In a 0.2% C. cast electric furnace steel the increase in tensile strength in the region between 20° and 400° C. occurred at a lower temperature and was more pronounced the faster the cooling from above the critical range before testing. SE (5c)

Malleableizing (5d)

Practice of Malleableizing Abroad (Aus der Praxis der Tempergiesserei im Ausland) *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, Apr. 15, 1934, pages 226-227. Paper particularly refers to American experiences in developing short-cycle malleableizing processes. Investigations by Hruska on surface decarburization of malleable cast Fe are summarized. Finally a method of the Belgian Kluijtmans for processing black heart malleable is described. GN (5d)

Malleable Castings. Albert Sauveur & Harry L. Anthony. *American Society for Metals Preprint* No. 4, 1934, 14 pages. Annealing treatments are described for producing castings with ferritic, pearlitic, sorbitic or spheroidized matrix. Tensile strengths in excess of 100,000 lbs./in.^{2} with 7% elongation are obtainable with an annealing treatment of 40 hours or less. WLC (5d)

Annealing of American Malleable Cast Iron in A Carburizing Agent (Glühen von amerikanischem Temperguss im Zementationsmittel). MAX PASCHKE & HEINZ SCHUSTER. *Die Giesserei,* Vol. 21, June 8, 1934, pages 237-242. Tempering tests carried out in the carburizing agent of Caron and in sand are reported which were made to find the best conditions for producing a high quality black malleable iron in the shortest possible time. The carburizing agent of Caron (60 parts of charcoal and 40 parts of barium carbonate) has been recommended to accelerate the disintegration of carbide; its effect was compared with annealing in sand. The results obtained with respect to graphitization of pearlite, duration of annealing as function of temperature, hardness as function of duration of annealing, and the equilibrium curves of the gases CO and CO_2 in presence of free C did not show an acceleration of carburization with the Caron agent as compared with the usual annealing in sand. This is explained by the fact that, in embedding the malleable casting in the Caron agent, the reactive surface Fe-gas is reduced, and the more so the finer the grain. In such case the carburizing agent is practically neutral. 8 references. Ha (5d)

Carburizing (5e)

Cementation Experiments with Different Metallic Carbides (Zementationsversuche mit verschiedenen Metallkarbiden). I. GAEFF. *Archiv für das Eisenhüttenwesen,* Vol. 7, Apr. 1934, pages 587-588. The depth of penetration of C into soft iron on 10 hr. carburization at temperatures up to 1260° C. in contact with which cast iron and the following carbides Fe-Mn, Fe-Cr, Cr, W, was studied. Diffusion of the C began only after dissociation of the carbides. SE (5e)

Recent Progress in Carburizing with Gas. R. J. COWAN. *Metal Progress,* Vol. 24, Oct. 1933, pages 44-48. Discussion of the use of mixtures of propane or butane with air and flue gas passed through heated tubes in the presence of suitable catalysts. WLC (5e)

Physical Properties of Case Hardened Steels. O. W. MCMULLAN. *American Society for Metals Preprint* No. 7, 1934, 62 pages. Reports studies of carburizing and medium C steels in fine and coarse grain types. S.A.E. 1020, 2315, 3115, 4615, 2512, 6115, 4820, Ni-Cr-Mo 1.75, 0.80, 0.40%. Krupp 4.0% Ni, 1.5% Cr and S.A.E. 4340, 4640, and 5140. 3 or 4 different depths of case were studied in each steel carburized with solid compounds and treated by quenching from pot, cooling in pot and giving single or double quench. 42 tables give physical properties, hardness, bending strength, impact strength, distortion, wear resistance and resistance of case to crushing. Single treated steels give lowest impact values and double treated the highest. Grain size and uniformity of structure in core has greatest influence upon impact values. Double treatment shows greater improvement in coarse steels. C content of case has little effect upon impact but increasing case depth results in decreasing impact values. Pot quenching gives highest file hardness and double treatment lowest, low hardening temperatures give highest Rockwell hardness. Distortion will be very regular if conditions are kept uniform. Case depth is greatest factor in distortion but its influence is minimized by pot quenching. Krupp, S.A.E. 2512 and 4820 show highest load carrying capacity when properly treated. They should not be pot quenched especially if deeply cased. Ni steels are best for shock resistance when unnotched but 4615 is best for notched impact. 4615 when fine grained is ideal for pot quenching. 6115 develops best properties by single quench. 1020 is low in strength and impact. 3115 has average strength and good wear resistance. Fine grained case-hardened steels are superior in strength and impact, in general. WLC (5e)

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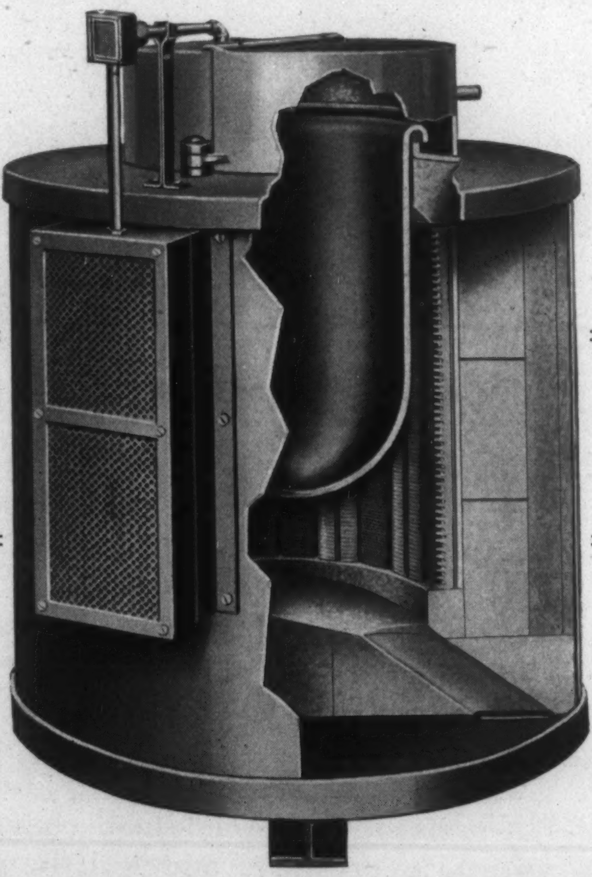

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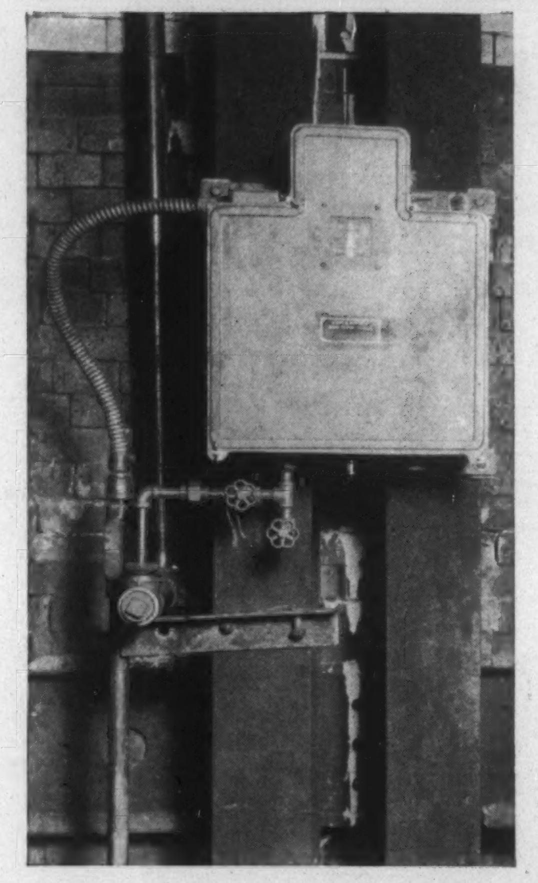

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FURNACES, REFRACTORIES & FUELS (6)

M. H. MAWHINNEY, SECTION EDITOR

Use of Steel Recuperators in Metallurgical Works (Anwendung von Stahlrekuperatoren auf Eisenhuttenwerken). J. MÜLLER-BERGHAUS. *Stahl und Eisen,* Vol. 54, Aug. 9, 1934, pages 822-827. The advantages of recuperator stoves made of high Ni-Cr heat resisting alloy for use up to 900°C over brick stoves are discussed. Two such specific installations for pusher type furnaces to heat ingots for rolling are described. In these furnaces with a capacity of 19 tons/hr. the alloy stoves gave 26% less operating costs than brick stoves; for a forging type furnace there was a 50% saving in gas consumption. An alloy regenerator stove is now being built for a 600 ton blast furnace. SE (6)

Industrial Furnaces. Vol. I. Third Edition. W. TRINKS. John Wiley & Sons, Inc., New York, 1934. Cloth, 6 x 9¼ inches, 456 pages. Price $6.00.

In this new third edition of a well known book, a wealth of new data has been added. W. Trinks, Professor of Mechanical Engineering at the Carnegie Institute of Technology, published the first edition of this volume in 1923, and thereby contributed one of the first, if not the first reference books on the subject of industrial furnaces. Some few other books have followed and, as pointed out in the preface, the design of industrial furnaces has been transformed from an art, characterized by "rules of thumb" to a science, where-in exact methods of calculation are available for the solution of most of the problems encountered in the design of an industrial furnace.

Professor Trinks' method is to digest the exceedingly complicated laws of heat transfer and kindred theory applying to furnaces, and to present the gist of the subject in the form of graphs, charts and tables. As a result of this method, requiring a mind at once both practical and highly theoretical, the various problems of heat flow which involve formidable higher mathematics are simplified and reduced to a form that can be applied by the furnace designer to his problems.

This third edition constitutes a complete revision of about two-thirds of the previous edition. This revision consists in the refinement and improvement in methods of calculating heat flow in the heating material, heat transfer within the furnace heat flow through furnace walls and openings, and the design of recuperators and regenerators. In all of these subjects, practical methods of solution are offered, with a thoroughly understandable description and explanation of the development of the method in every case.

The book applies to the design of all kinds of heating furnaces (not including melting furnaces) and the subject matter includes capacity of furnaces, fuel economy, heat saving appliances, movement of gases in furnaces, and the strength and durability of furnaces. From this outline it may be seen that the book deals principally with the theory of operation and interior design. The features of furnace binding, lining, mechanical parts, both inside and outside the furnace, are discussed in one chapter but not with the precision which characterizes the remainder of the volume.

In conclusion, this edition is a major improvement over the previous editions, which themselves have been of great assistance to the designers and users of industrial furnaces. M. H. Mawhinney. (6) -B-

The Experience of Gray Iron Jobbing Foundry With the Rocking-Type Electric Furnace. C. R. CULLING. *Transactions American Foundrymen's Association,* Vol. 5, Apr. 1934, pages 519-534. The rocking type electric furnace is convenient for use in the jobbing foundry. An improved product with higher strength, increased density and improved machineability free from slag and oxide inclusions, superheated under a deoxidizing atmosphere is available. Control of chemical and physical qualities is definite. Flexibility of the rocking electric furnace is shown by the wide range of chemical analysis covered in production of the regular grades of higher strength materials. It was found practical and economical to produce small batches of metal for special purposes or to produce a larger quantity of base mixture and progressively change the bath to suit different requirements. By using the furnace described it has been found possible to serve customers consistently without waiting for larger accumulations of tonnage necessary for the operation of the cupola. CEJ (6)

Electric Melting and Heating Furnaces in the Metal Industry (Elektriska smälte och varmeugnar för metallindustrien). V. CHRISTIANSEN. *Teknisk Tidskrift,* Vol. 64, July 14, 1934, pages 285-290; July 21, 1934 pages 293-297. Paper presented at the annual meeting of the Swedish Technical Society. Deals with the various types of arc, induction, and resistance furnaces used in metallurgy. Heroult furnace, Detroit furnace, and Rennerfelt furnace discussed. Gives a thorough description of the Ajax-Wyatt induction furnace. At Finspong Metallverk, Sweden, this furnace is used for melting brass, bronze, and copper. Usual life of lining for brass 5,000-15,000 melts, but as high as 37,000 melts has been attained with one lining, lasting about 6 years. Experiments to develop lining for metallic copper melts have resulted in life of 600-1,200 melts. Use of crucibles sintered directly in furnace has reduced crucible cost considerably. Description is also given of a Bailey furnace with crushed graphite for resistance material, handling 2,500 kg. Al per 24 hr., with 80-120 kw. and 55 volts. Electric annealing furnaces, always of the resistance type, offer advantages of superior product and simplified operation. A 200-300 kw. furnace for annealing brass, capacity 12-24 tons/24 hr., and furnaces for annealing wire during drawing, such as the Kenworthy and the Grünewald furnace are also described. BHS (6)

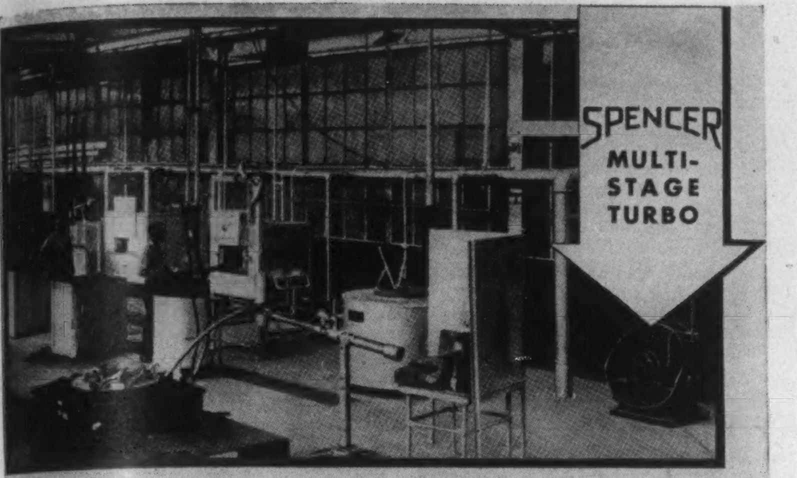
Refractory Materials for Severe Requirements (Hochfeuerfeste Baustoffe für stärkste Beanspruchungen) *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, May 20, 1934, pages 292-293. Discusses properties and application of refractory materials on Si-C base. Due to high heat conductivity Si-C products are particularly suited for indirect heating furnaces as, for instance, muffle furnaces. GN (6)

Blast-Furnace Linings. Extracts from Special Report No. 7. *Iron & Coal Trades Review,* Vol. 128, June 1, 1934, pages 879-881. The report deals with some properties of the fireclay products used for blast-furnace linings. Tables giving compositions of lining, place where used in the furnace, production of the furnace and dimensions, are compiled from questionnaires and the influence on the life of linings is discussed. No general conclusions can be drawn. Ha (6)

Installs One-Way Oil Fired Soaking Pits. *Blast Furnace & Steel Plant,* Vol. 22, Mar. 1934, page 158. Brief description of installation to be made at plant of American Steel & Wire Co. in Worcester, Mass., by Surface Combustion Co. MS (6)

Heat Consumption of Open-Hearth Furnaces. R. D. ABBISS. *Iron Age,* Vol. 133, May 24, 1934, pages 31, 42. Abstract of paper read before the annual meeting of the American Society of Mechanical Engineers. Gives data on heat transfers in open-hearth furnace operation and in particular heat exchanges of checker brickwork. VSP (6)

The Construction of Electric Resistance Furnaces. G. W. ASHTON. *Machinery,* London, Vol. 44, Apr. 26, 1934, pages 97-99. Advantages and working principle of electric resistance furnaces. Resistance alloys. An alloy of 80% Ni and 20% Cr can be used for temperature up to 1100°C.; 65% Ni, 15% Cr, 20% Fe up to about 950°C Kanthal will work at temperatures up to 1350°C. Discussion of the construction of furnaces and materials used. Kz (6)



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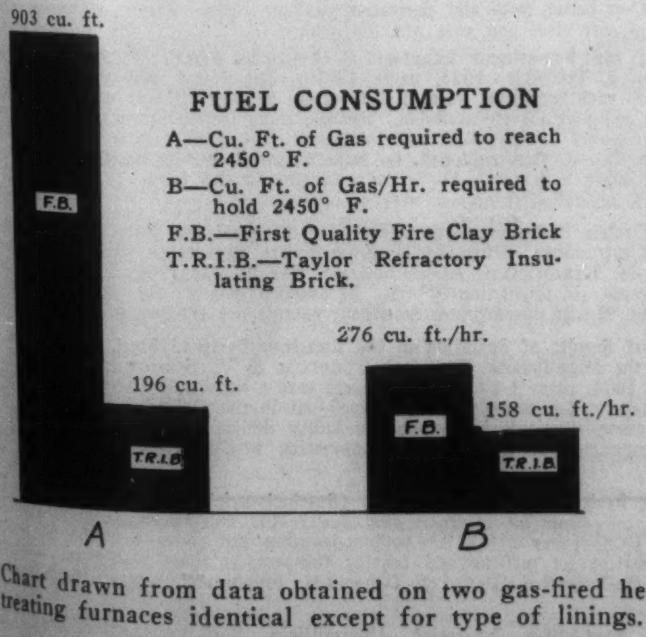

Chart drawn from data obtained on two gas-fired heat treating furnaces identical except for type of linings.

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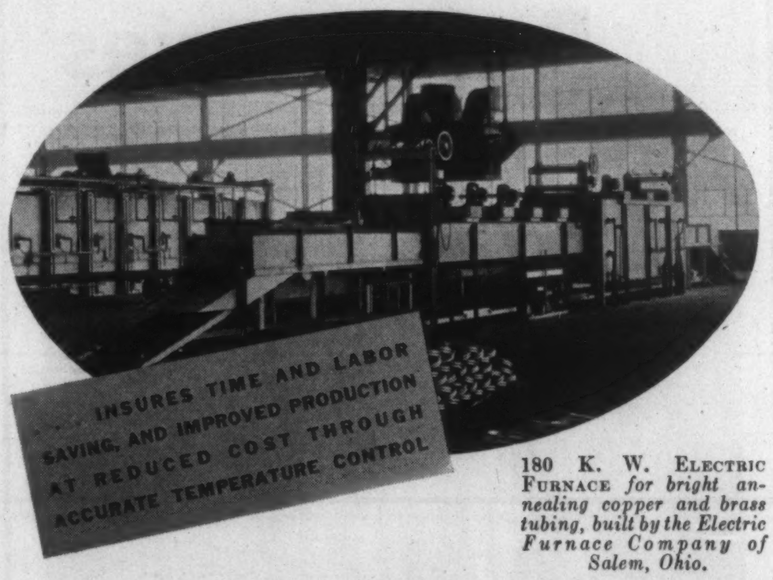
THIS ELECTRIC BRIGHT ANNEALING FURNACE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TWO STEPS are eliminated in the production of bright copper tubing and bright brass tubing in this electric furnace, built by the Electric Furnace Company of Salem, Ohio, for the plant of a large American copper company. Accurate heating and cooling in an artificial atmosphere replace the pickling and washing processes usually required to impart a bright surface to the finished product.

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Armstrong's . . **EF** . . *Nonpareil Brick*

Where conditions are most destructive

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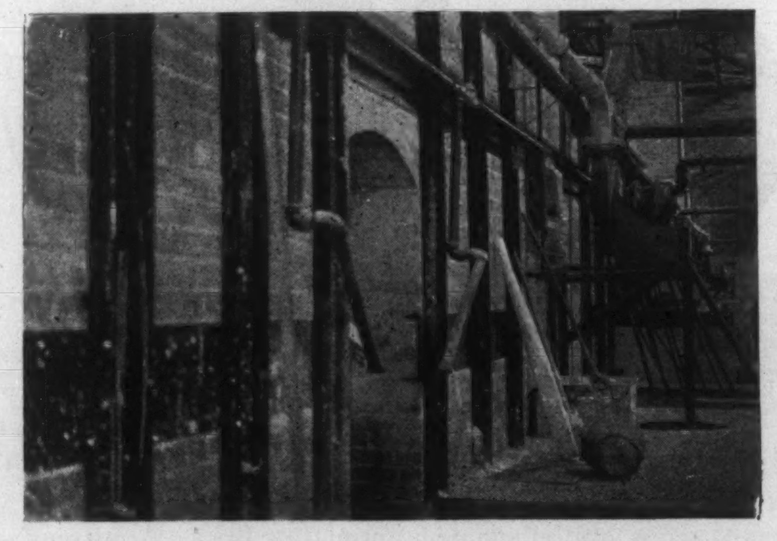

View along pouring side of very modern Smelters, completely built of "ALUMITE" Refractories

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Electric Bright-Annealing Furnaces. TAMELE. *Heat Treating & Forging,* Vol. 20, July 1934, pages 355-357. Translation from *Elektrowärme* published in *Sheet Metal Industries.* See "Recent Developments in Electric Bright-Annealing Furnaces," *Metals & Alloys,* Vol. 5, June 1934, page MA 262. MS (6)

Factors Affecting the Service of Clay Refractories in Iron Foundries. R. C. ZEHM. *Transactions American Foundrymen's Association,* Vol. 5, Apr. 1934, pages 497-499. Refractories used in iron foundries generally made from fireclay and grog consisting of calcined clay and burned brick or fireclay shapes. Mixing and grinding aid in blending and improve quality of final product. The methods of forming, i.e., the hand-made, the stiff mud, and the dry press process each influence properties of finished material. Upper part of cupola requires a refractory resistant to mechanical shock and abrasion while melting zone requires a refractory to withstand temperature and slag action. CEJ (6)

Annealing Malleable in Small Furnace Proves Economical. L. J. WISE. *Steel,* Vol. 95, Aug. 6, 1934, pages 45-46. Oil-fired, 10-ton oven holding 12 stacks of pots has walls of 9-in. refractory insulating brick backed up by 3½ in. of secondary insulation. Crown is 9-in. firebrick covered with 4 in. of secondary insulation. Total time of annealing is 96 hrs. Packing material is used in all pots. MS (6)

Coal Washing Benefits Coke Oven Operation. H. W. SEYLER. *Chemical & Metallurgical Engineering,* Vol. 40, Sept. 1933, pages 471-473. Benefits derived from washing raw coal for coking purposes are described. They include 10-15% improvement in physical qualities of metallurgical coke, a reduced content of S and ash, a 5-8% reduction in coke consumption in blast furnace practice, as well as 5-10% reduction in flux, 7-12% reduction in slag volume, 5-8% reduction in blast pressure, 5-8% increase in production of a lower sulphur pig iron. By-products are improved, for instance there is a 20% reduction of H_2S in coke oven gas. PRK (6)

New Developments in Electric Bright-Annealing Furnaces. OBERING TAMELE. *Sheet Metal Industries,* Vol. 8, Aug. 1934, pages 450-452. Discussion of the Siemens-Prufert bright-annealing process. The charge is transferred to a special cooling tank in which an inert atmosphere is readily built up by burning a paraffin rag. This liberates the furnace for another charge while the charge cools down in something like a small gasometer. Adoption of axial heating elements for annealing coils is discussed. AWM (6)

New Developments in Electric Bright-Annealing Furnaces. OBERING TAMELE. *Sheet Metal Industries,* Vol. 8, July 1934, pages 391-392. Discusses applications of Siemens-Stassinet bright annealing furnaces. AWM (6)

Cupola Refractories. EDWARD E. MARBAKER. *Transactions, American Foundrymen's Association,* Vol. 5, Apr. 1934, pages 491-494. Economy will result when cupola is properly lined, maintained and operated. In melting zone a highly refractory lining material laid with as few and as narrow joints as possible is vital. Tap-out or slag-hole blocks installed as an integral part of the cupola lining must be capable of resisting slag action and mechanical abrasion. With lining maintenance costing roughly twice as much as the actual lining of the cupola the use of high quality fire clay is most effective. CEJ (6)

The Utilization of Magnesian Carbonates. F. E. LATHE. *Engineering Journal,* Vol. 16, Dec. 1933, pages 501-506. Outlining the history of the magnesian refractories industry in Canada during the last 30 years the paper explains the development of a method of eliminating silica and lime from the magnesite rock obtained near Grenville, Que. The work was carried out by the National Research Council. The refractory developed for open hearth furnaces had the following composition: CaO 17.5-21.5%, iron oxide (calculated to Fe_2O_3) 6.5-7.5%, SiO_2 5.5-7%, MgO 63-68%. Refractory brick, plastic magnesia for flooring and stucco and other materials were developed. VVK (6)

Effect of New Insulating Methods and Insulating Materials (Betrachtung über die Wirkungsweise neuer Isoliermethoden und Isolierstoffe). OTTO KREBS. *Elektrowärme,* Vol. 4, June 1934, pages 129-132. Protection against heat losses is recently effected by thin, highly polished metal strips (alfol-insulation), by slag-wool, and by finely ground materials of blast-furnace dust and kieselguhr. The highly polished surface of the insulating material radiates less heat than that of a material with rough and dull surface. Ag, Cu, Al have in polished state a radiation loss of only 0.19-0.27 kcal./m.^{2}/hr./°C. against about 4.4 for dull material. Al-foil of 0.03-0.05 mm. is wound at a distance of about 10 mm. around the object to be protected. Slag-wool acts in the same manner, the brilliant white threads and the enclosed airspaces give excellent insulation; the weight is 170 kg./m.^{3} with 95% porosity. Blast-furnace dust is treated in ball mills and sorted, weight varies from 285 to 600 g. per l, according to constituents. Experiments made and curves of heat conductivity for different temperatures are given. Ha (6)

Grate-Bar Consumption in Dwight-Lloyd Sinter Bands (Der Roststabverbrauch bei Dwight-Lloyd-Sinterböndern). M. PASCHKE & E. SCHIEGRIES. *Stahl und Eisen,* Vol. 54, July 26, 1934, pages 773-777. The protective oxide coating which tends to form on the grate bars is broken down by sulphurous gases, jolting, and sharp temperature changes, so that the bars get thinner and fail. Coating with lime, or better, with clay decreased breakage. There was no difference between the life of soft steel and cast iron grate bars. SE (6)

Against the Non-critical Adoption of American Practice. N. KLIZHEVICH. *Stal,* Vol. 4, Feb.-Mar. 1934, pages 14-15. The author believes that the thick walled bosh with horizontal water jackets of Cu is practical only where mechanically good coke and pure Cu are available. Because these factors are missing at Magnitogorsk, the use of a thin-walled bosh with vertical cast-iron water jackets is urged. On furnace No. 3, thus equipped, no jackets burned out in the first 5 months of operation, while on furnace No. 1, with a thick-walled bosh, 102 burned out in 14 months, several after only a week of operation. HWR (6)

Some Electric Heat-Consuming Processes of Chemical and Metallurgical Industries (Einige Elektrowärme verbrauchende Prozesse der chemischen und metallurgischen Technik). H. KIRCHRATH. *Elektrowärme,* Vol. 4, May 1934, 110-115. Furnaces and apparatus for production of CS_2, P, alumina cement, Zn, Sn, distillation of metals (Zn, Mn in vacuum) are described; patents are enumerated. Ha (6)

The First Results of Operation of the American Designed Blast Furnaces Nos. 1 and 2 of the Magnitogorsk Plant. C. ILDRIUM & V. SOROKIN. *Stal,* Vol. 4, Feb.-Mar. 1934, pages 1-13. These furnaces have a thick-walled bosh with horizontal water jackets of Cu, many of which burned out in the first year of operation. The authors believe that this is not due to faulty design, but to irregular supply of water, inexperience of employees, and operating without replacing the burned-out sections. HWR (6)

Charging Devices for Heating Furnaces (Beschickvorrichtungen für Wärmöfen). H. KALPERS. *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 25, May 13, 1934, pages 276-277. Author describes and shows a number of modern charging devices for melting and heating furnaces as those of Demag, Duisburg, Bamag, Köln-Bayenthal, Dango & Dienenthal, Siegen and Nomag, Duisburg-Hamborn. GN (6)

Modern Feed-Water Treatment (Neuzeitliche Speisewasseraufbereitung). K. HOFER. *Stahl und Eisen,* Vol. 54, July 5, 1934, pages 701-708, July 12, pages 729-736. A general discussion of the treatment of feed-water in high-pressure boilers and methods of testing feed and boiler-water. SE (6)

Putting into Operation and Mastering Blast Furnace No. 1 of "Azovstal" (Ordzhonikidze Plant). Y. GUGEL & N. KAPORULIN. *Stal,* Vol. 4, Jan., 1934, pages 17-30. Details of the operation of a new furnace producing 750 tons daily with a coke to pig ratio of 1.1-1.2. Minor defects in the design are pointed out. HWR (6)

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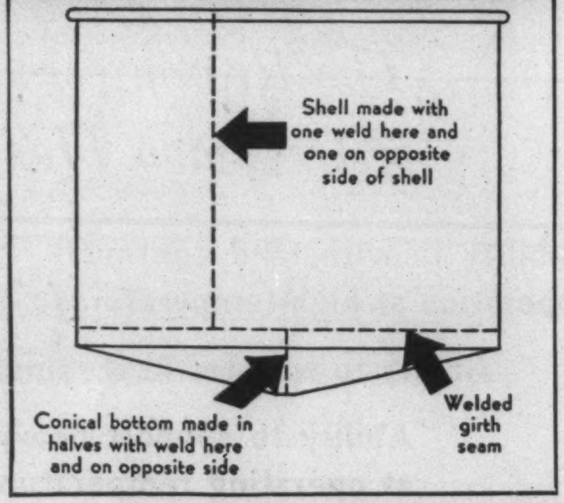
Shell made with one weld here and one on opposite side of shell
Conical bottom made in halves with weld here and on opposite side
Welded girth seam

THE fabricator who built three Nickel kettles like the one illustrated writes: "These kettles were gas welded with 'T' Nickel gas welding wire and the seams were hammered, ground smooth and polished.

"The kettles had two longitudinal welds and one girth seam welded. The bottoms were butt welded to the sides.

"The seams in the coils were also gas welded and there we also used 'T' Nickel gas welding wire. The coils were made of about 3 pieces and had pure Nickel nipples (of iron pipe size) gas welded to the ends."

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for MONEL METAL

Oxy-Acetylene...Monel Gas Welding Wire. (For flux, see * below.)
Metallic Arc...INCO Monel Metallic Arc Welding Wire No. 30.
Carbon Arc...INCO Monel Carbon Arc Welding Wire No. 20.

for INCONEL

Oxy-Acetylene...Inconel Gas Welding Wire. (For flux, see ** below.)
Metallic Arc...Inconel Metallic Arc Welding Wire No. 32.

for NICKEL-CLAD STEEL
(for welding of Nickel side)

Oxy-Acetylene..."T" Nickel Gas Welding Wire.
Metallic Arc...INCO Nickel Metallic Arc Welding Wire No. 31 and No. 35†
Carbon Arc...INCO Nickel Carbon Arc Welding Wire No. 21.

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** "Cromalloy" Gas Welding Flux is recommended for Inconel.
† For vertical welding.
No flux is used for the gas welding of Pure Nickel or Nickel-Clad Steel.

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JOINING (7)

Welding & Cutting (7b)

C. A. McCUNE, SECTION EDITOR

Galvanized Piping. *Oxy-Acetylene Tips,* Vol. 12, June 1933, pages 133-135. Experience seems to point to the fact that welding galvanized pipe does not affect corrosion resistance or strength of the pipe itself, immaterial whether steel or bronze welding rods are used. Except the piping being exposed to highly corrosive mediums no accelerated corrosion will take place. Electrolytic corrosion can be prevented by grounding the pipe. A few examples are described. Ha (7b)

Welding of Steel Bridges (Schweissen von Stahlbrücken). *Montanistische Rundschau,* Vol. XXVI, July 16, 1934, (Section *Stahlbau-Technik*) page 4. Brief review of a lecture by A. Domen in Essener Haus der Technik in which he discussed the development of welding in bridge construction up to the present time, based on over 30 completed installations, with a brief treatment of the shrinkage stresses in such welded structures. BHS (7b)

The Bridge Across the Albertkanal at Lanaye (Die Brücke über den Albertkanal bei Lanaye). *Montanistische Rundschau,* Vol. XXVI, July 16, 1934 (Section *Stahlbau-Technik*), pages 3-4. Abstract of a report by H. F. N. Santilman in "Annales des Travaux Publics de Belgique," Dec. 1933, part of which also appeared in *Zeitschrift des Österreichischen Ingenieur- und Architekten-Vereines,* No. 23 and 24, 1934. Gives details in connection with the electric welding done in the construction of the bridge. BHS (7b)

Fused Welded Boiler Drums. *Journal of Commerce (Shipbuilding & Engineering Edition)* May 31, 1934, page 3. A brief description of the procedure, treatment, and method of X-ray examination adopted in the manufacture of boiler drums (for the U. S. Navy) by electric arc welding. Complete drums were subjected to many times their working pressure and to fatigue tests to show their reliability, and a series of such tests are given. JWD (7b)

Welding Terms and Methods. *Chemical Trade Journal & Chemical Engineer,* Vol. 93, Sept. 15, 1933, page 194. In order to define and establish the exact meaning of terms used in welding practice and to develop a standard system for indicating styles and types of welds on engineering drawings. British Standards Institution has issued "Standard Nomenclature, Definitions, and Symbols for Welding and Cutting" as publication No. 499. JN (7b)

Repair Welding of Cast Iron (Ausführung einer Gusseisen-Reparaturschweissung). H. BUSCHMANN. *Autogene Metallbearbeitung,* Vol. 27, May 15, 1934, pages 163-165. Fracture of big castings of a caterpillar dredge was repaired by welding with soft iron rod; procedure is described in detail. Ha (7b)

Spheres for Joining Tubes. A. F. BURSTALL, R. A. SMITH & HAROLD KENNEY. *Product Engineering,* Vol. 5, July 1934, pages 261-262. Tubular members of a welded structure are joined by welding them to a common spherical member which assures joints at right angles, the line of contact being a circle. Absence of eccentric stresses permits higher working stresses. Design of the spheres and procedure of welding are described. Ha (7b)

Electric Welding (La Soudure Electrique). JEAN BRILLIÈ. *Revue de la Soudure Autogène,* Vol. 26, Apr. 1934, pages 6-9. Lecture at the "Conservatoire National des Arts-et-Métiers," Mar. 16, 1934. Author reviews the different processes available: resistance welding, arc welding, H atomic welding, etc., and gives characteristics of each. FR (7b)

Restrained Dimensional Changes in Welded Seams (Behinderte Formänderung in Schweissnähten). F. BOLLENRATH. *Stahl und Eisen,* Vol. 54, June 14, 1934, pages 630-634. An analysis of stress distribution around the welded seams in plates. The internal stresses may rise well above the elastic limit before they are released by flow. However the internal stresses themselves seldom give rise to fracture unless they are accompanied by structural defects, aging, decarburization, etc. SE (7b)

Internal Stresses in Welded Seams (Eigenspannungen in Schweissnähten). F. BOLLENRATH. *Stahl und Eisen,* Vol. 54, Aug. 23, 1934, pages 873-877. The internal stresses in plates of structural steel after fusion welding by V butt-welds were determined. With the narrower heating zone in electric-arc welding the internal stresses were greater than with the wider heating zone in gas welding. Solidly fastened plates gave higher stresses than freely moving plates; thicker plates higher stresses than thinner. SE (7b)

Spot and Seam Welding of Aluminum and Aluminum Alloys. D. I. BOHN. *Sheet Metal Industries,* Vol. 8, July 1934, pages 426-428. Paper read to the New York section of the American Welding Society. High electrical conductivity of Al demands exceedingly high amperage. High thermal conductivity necessitates extremely short time of power application to avoid general heating and collapse when melting is reached. Means of fulfilling these requirements are discussed. AWM (7b)

Arc Welding. D. S. BLACK. *Electrical Review,* Vol. 115, July 20, 1934, page 82. Brief discussion of selection of equipment and rods, testing of welds, training of operators, and methods of payment. MS (7b)

Experiments to Determine Shrinking Stresses in Butt-Welded Joints (Versuche zur Ermittlung der Schrumpfspannungen in geschweissten Stumpfnahtverbindungen). G. BIERETT. *Zeitschrift Verein deutscher Ingenieure,* Vol. 78, June 9, 1934, pages 709-715. According to present knowledge it must be assumed that electric arc welding always produces high longitudinal stresses with the usual welding rods, and gas fusion welding lower, but still considerable longitudinal stresses. These stresses can be controlled to a much lesser degree than transverse stresses by welding methods, although their reduction is desirable particularly if additional tensile stresses occur in service, as in boilers and girders. Complete heat treatment is generally impossible; it should be investigated whether local heating by a torch reduces the maximum stress which occurs some distance from the seam. A proper selection of the material to be welded and also of the electrode and welding rod may result in lower original longitudinal stresses and equalization at lower temperatures. The relation between longitudinal and transverse stresses is discussed, the utilization of shrinking phenomena might lead to greater safety and admission of higher stresses in order to increase the economy of welded structures. Ha (7b)

Arc Welding of Hydronalium (Beitrag zur Kenntnis der elektrischen Lichtbogenschweissung von Hydronalium). L. ANASTASIADIS. *Die Elektroschweissung,* Vol. 5, May 1934, pages 96-99. Author first considers difficulties arising in welding Al and Al alloys. In acetylene welding Hydronalium (5-10% Mg, 5% Mn, Si as impurity, balance Al) the material becomes superheated near the weld seam, the smooth surface is roughened and covered with numerous small gas holes. Author investigated how these gas holes can be avoided and what physical properties can be attained. Proper welding procedure of Hydronalium is described. For better comprehending metallurgical occurrences in welding Hydroalium Al-Mg diagram is considered at length. Elongation and tensile strength of the welds correspond to the average values of non-welded cast alloys. Finally corrosion tests were made in a 3% NaCl solution containing 1% H_2O_2. It results that tensile strength and elongation of samples subjected to this corrosion medium for 12 days did not decrease. A heavier corrosion attack was apparent in welded samples showing no smooth surface. These spots were covered with a white flaky corrosion product. This occurrence appeared not only on welds but on the material itself. GN (7b)

Welding Tests. *Shipbuilding & Shipping Record,* Vol. 44, Aug. 9, 1934, pages 153-154. A review of tests shows the evolution of weld test specimen forms as originally applied by the American Bureau of Shipping and as related to the amplification of such standards by tentative specifications issued by the American Welding Society. Hull construction welding only is included. JWD (7b)

Light-Weght Design with Shot-Welded Stainless Steel. *Product Engineering,* Vol. 5, July, 1934, pages 242-245. Light-weight design can be obtained with different materials, wood, aluminum or alloy steel, but for each material the proper design principles and methods of construction must be applied. The advantages of stainless steel, 18 Cr-8 Ni, for this purpose are explained; in its application care must be taken that the corrosion resistance of the material is not destroyed by heating to too high temperatures which causes the precipitation of Cr carbide at the grain boundaries so that the metal adjacent to the grain boundaries is robbed of its Cr content. This is avoided by the "shot-welding" process of the Budd Manufacturing Co. an arc-welding process whereby the material is brought to fusion temperature with great rapidity and then also cooled rapidly so that there is no time for precipitation of Cr carbide. Examples of built-up shapes and other applications are described. A properly made shot-weld will have a shear-strength of 90,000 lbs./in.^{2} Ha (7b)

Welding Corrosion-Resisting Steels. *Oxy-Acetylene Tips,* Vol. 12, June 1933, pages 125-129. The welding procedures for various high-Cr alloys are described in detail: 1. stainless steel, 12-15% Cr, about 0.3% C; 2. rustless or stainless Fe, 11.5-15% Cr, max. 0.12% C; 3. stainless Fe, 15-18% Cr, 0.5-1.25% Si, max. 0.5% Mn, max. 0.1% C; 4. 18-8 alloy, 16-20% Cr, 7-12% Ni, max. 0.75% Si, max. 0.65% Mn, max. 0.12% C; 5. 24-12 alloy, max. 0.25% C, 20-30% Cr, 10-22% Ni, 0.5-1.5% Si; 6. alloy with 0.3-0.5% C, 21-25% Ni, 7-9% Cr, 1-1.5% Si, 1-1.5% Cu; 7. chrome-iron, max. 0.3% C, 24-30% Cr, 0.5-1.0 Mn, max. 0.6% Si; 8. Castings. Advantages of welded stainless steel products with respect to better saleability and longer life are pointed out. Ha (7b)

Welded Boiler Drums and Steam Receivers. *Engineer,* Vol. 157, Feb. 2, 1934, page 122. From paper read by C. H. Davy before the Institution of Welding Engineers, London, Jan. 10, 1934. See "The Development of Welding as Applied to Boiler Drums and Steam Receivers," *Metals & Alloys,* Vol. 5, Sept. 1934, page MA 447. LFM (7b)

Manufacture of Water Turbine Housing by Welding (Herstellung eines geschweissten Zellen-Radgehäuses). E. Sakals. *Autogene Metallbearbeitung,* Vol. 27, May 15, 1934, pages 165-166. Describes procedure. Ha (7b)

Successfully Fabricate Stainless Steel for Many Purposes. W. J. Wachowitz. *Steel,* Vol. 95, July 30, 1934, pages 25-27. Discusses use of welding for fabrication of solid stainless and stainless-clad steel equipment and describes some large units built by author's firm. It is essential to have welding-machine run at rated speed, and generator cleaned periodically. Stainless-clad steel is much easier to weld than solid stainless sheet if proper method is used, and work strains do not develop as readily. MS (7b)

Constructing the Bouquet Canyon Pipe Line. H. A. Van Norman. *Civil Engineering,* Vol. 4, June 1934, pages 306-310. A description is given of the methods used in welding this pipe line which is 7-8 ft. in diameter, 3½ miles long, laid in very precipitous country, and includes an inverted siphon with a static head of 870 ft. JCC (7b)

Applications of Oxyacetylene Welding (Les Applications de la Soudo-Brasure). R. Meslier. *Revue de la Soudure Autogène,* Vol. 26, Apr. 1934, pages 4-5. In spite of use of low melting added metal such as "Brox Metal" (melting temperature 880° C.) welding with such metal was used with success in repair of city gas retort heads and other retort parts which work at temperatures within the range 600°-700° C. Details of repair are given and illustrated. FR (7b)

Possibilities of Fusion Welding in Installations for Industrial Heating (Les Possibilités de la Soudure Autogène dans la Construction du Matériel et les Installations de Chauffage Industriel). R. Meslier. *Revue de la Soudure Autogène,* Vol. 26, Mar. 1934, pages 2-5. Paper read at 3d Congress of Industrial Heating, Paris Oct. 9-14, 1933. Author shows necessity of correct selection of welding process in each particular case. He shows that welds obtained have high qualities and reviews applications of welding processes in construction and maintenance in industrial heating installations. FR (7b)

Fusion Welding of Non-Ferrous Metals (Zur Autogenschweissung der Nichteisenmetalle). Hans Melhardt. *Der Autogen Schweisser,* Vol. 7, Apr. 1934, pages 38-43. Discussion of points which determine changes in welding technique when employed in the welding of the different non-ferrous metals. The melting points and heat conductivity of the metals determine the choice of burners and gas to be used in fusion welding or necessity for preheating in certain cases. The regulation of the flame and the application of fluxes to prevent gas inclusions are discussed. Choice of welding rods in welding of alloys and in built-up repair work. Changes in mechanical properties of metals at different temperatures influence the welding technique. Dealing with recrystallisation the thermal and mechanical treatment of welds is discussed. Kz (7b)

Coated Electrodes in Arc Welding. J. E. Waugh. *American Machinist,* Vol. 78, July 4, 1934, page 469. Heavily coated electrodes improve ductility, impact and fatigue strength and corrosion resistance of welds over those made with bare or lightly coated electrodes; a table shows comparative figures. The improvement is due to the shielding of the molten metal while passing through the arc, thus eliminating formation of oxides and nitrides at the arc temperature. It is advantageous to make the individual layers or passes of the weld relatively thin (about ⅛"). A further improvement of the weld can be obtained by a strain relief anneal at 1200° F. Ha (7b)

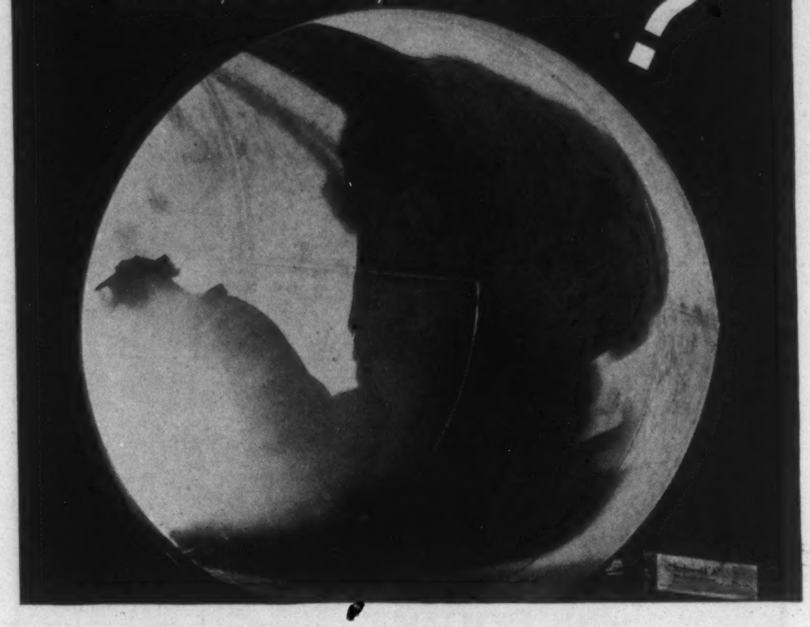
The Welding of Lead (Das Schweissen von Blei). Lüder. *Zeitschrift für Metallkunde,* Vol. 26, Apr. 1934, page 93. Gas welding of Pb is most satisfactory; either hydrogen-air or hydrogen-oxygen mixtures are used, without applying flux. Pb hardened with Sb is sometimes used. Tables are given for welding times for tubes of various diameters, and for welds of different design. RFM (7b)

Details of Design and Construction of the World's Largest Welded Bridge. R. W. P. Leonhardt. *Welding Engineer,* Vol. 19, July 1934, pages 23-25. Illustrated description of a 1040 ft. long bridge in 13 spans, each of from 72.5 to 86 ft. long, Methods of welds, manual and automatic, and the electrodes used for different thicknesses, consumption of electrodes, are tabulated. Ha (7b)

Modern Barrel Welding Devices. Rene Leonhardt. *Sheet Metal Industries,* Vol. 8, Aug. 1934, pages 483-485. Discussion of the welding of oil barrels with the electric arc and pure carbon electrodes. Hand-controlled, semi-automatically controlled, and fully automatic layouts are discussed. AWM (7b)

Arc-Welding of Copper (Die Lichtbogenschweissung von Kupfer). Fr. Neumann. *Zeitschrift Verein deutscher Ingenieure,* Vol. 78, June 2, 1934, pages 667-668. The difficulties of arc-welding Cu owing to the great heat conductivity of the metal are pointed out, it is possible only if the material is preheated to 400° C. Experiments were made with high melting electrodes in order to supply in this manner more heat to the material; Cu-Ni electrodes gave satisfactory welds but were expensive and cause danger of corrosion on account of the electrolytic potential difference with the material. The only practical way for increasing the heat supplied to the material was found by increasing voltage of the arc; 30-40 volts and 250-300 amp. gave welds with good structure with only little coarsening of the grain, no separating line was visible. Preheating was not necessary in this process and welding velocity was high. Ha (7b)

WANT BETTER WELDS
in 18% Cr.-8% Ni. Steels?



Better welds in 18-8 stainless steels possess these properties . . .

Tensile Strength . . . 85,000 to 95,000 lbs. per sq. in. with yield point of 30,000 to 40,000 lbs. per sq. in.

Ductility . . . 50% to 60% elongation in two inches. Bending weld 180°, as shown at right, reveals no sign of weld failure.

Impact Resistance . . . 100 to to 120 ft. lbs. (Izod).

Density . . . as measured by specific gravity, 7.86 grams per c. c.

Corrosion Resistance . . . hundreds of tests prove weld resistance to corrosion equal to the plate. Welded 18-8 plate, as shown at right after corrosion, reveals no greater deterioration of weld than of plate.

Appearance . . . when ground smooth and polished it is practically impossible to distinguish the weld from the 18% Cr-8% Ni steel it joins. No pinholes or discoloration to reveal the weld or mar the polished surface.

Compare all the above values with the average properties of 18-8 steels.

How to Obtain . . . weld metal possessing all the above characteristics is produced by the shielded arc with Lincoln "Stainweld A" electrodes. Such welds can be made in *any* position—flat, horizontal, vertical and over head . . . with "Stainweld A" electrodes.

Free samples of "Stainweld A" with complete procedure for welding are available upon request addressed to

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FINISHING (8)

H. S. RAWDON, SECTION EDITOR

Cleaning, including Sand Blasting (8b)

Cleaning Metal Parts. *Industrial Finishing,* Vol. 10, Nov. 1933, pages 9-12. A discussion of the character and source of various kinds of dirt encountered in metal-cleaning practice and their removal by cleaning solutions preparatory to finishing. Several types of continuous cleaning machines are described. JN (8b)

Rinsing of Metal Objects in Surface Cleaning (Ueber das Spülen bei der Oberflächenveredlung von Metallgegenständen). H. KRAUSE. *Mitteilungen des Forschungsinstituts und Probieramts für Edelmetalle,* Vol. 8, May/June 1934, pages 24-28. The importance of using pure running water for rinsing metal objects is emphasized. Water in tanks very soon accumulates too much dirt, bath liquid, etc., and since the surface is incompletely cleaned, proper deposition in electroplating is not obtained. Particular care must be given to porous objects, as castings. Practical hints for cleaning and drying are added. Ha (8b)

On the Application of Compressed Air Tools in the Foundry (Ueber die Verwendung von Pressluft-Werkzeugen in der Giesserei). *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, June 10, 1934, pages 241-244. Paper discusses application of compressed-air tools for (1) removing casting cores (2) removal of casting fins, (3) grinding of casting seams. Construction and operation of air hammers and grinding wheels for these purposes are considered at length. Various types of implements are described, special reference being made to those of Deutsche Niles-Werke, Berlin-Weissensee. GN (8b)

Cleaning Aluminum and Tin. *Platers' Guide,* Vol. 30, Aug. 1934, pages 20-21. Na-metasilicate is much less corrosive on Al and Sn than any other alkaline cleaner. Results:

For Al:		
1% solution at 212° F.	pH	Wt. loss
Caustic soda (NaOH)	13.2	0.6500 g.
Na-metasilicate	12.2	0.0005 g.
Trisodiumphosphate	11.8	0.1030 g.
Soda ash	11.5	0.11 g.
For Sn:		
.24% solution at 180° F.	10.0	
Sodium sesquicarbonate	10.0	0.0084 g.
Na-metasilicate	11.6	0.0004 g.
Trisodiumphosphate	11.5	0.0200 g.
Soda ash	11.1	0.0126 g.

WHB (8b)

Polishing & Grinding (8c)

Grinding Oils (Schleiföle). K. KREKELER. *Oberflächentechnik,* Vol. 11, May 15, 1934, page 115. The function of a liquid used in grinding is to cool and lubricate, lubrication being less important than cooling. The cooling agent should protect the specimen and machine from rust. A ratio of oil to water in a grinding emulsion of 1:60 is best for rust prevention. The oil should be well emulsified. Ha (8c)

Round-Grinding (Rundschleifen). G. KAESER. *Oberflächentechnik,* Vol. 11, May 15, 1934, pages 114-115. Practical points on hardness, grain size of grinding material, diameter of grinding wheels, speeds, energy consumption, wages, and cost as dependent on kind of work and material to be ground and polished, are reviewed. Ha (8c)

Electroplating (8d)

Electrodeposition of Chromium from Aqueous Chromic Acid Solutions (Ueber die elektrolytische Abscheidung des Chroms aus wässerigen Chromsäurelösungen). F. J. WEBER. *Oberflächentechnik,* Vol. 11, June 5, 1934 pages 123-127. Previous investigations of the current efficiency and effect of foreign acids in Cr plating baths (see G. C. Schmidt & F. J. Weber, *Oberflächentechnik,* Vol. 9, 1934, page 189) were continued. The influence of temperature, current density, concentration of chromic acid, nature and concentration of additions was considered. Brilliant deposits of Cr were obtained at 20° C. only with low current density if H_2SO_4 was present current efficiency was small. Higher current density produced dull deposits. At 40° C. the deposits were bright even with a wide range of current density and amount of added H_2SO_4. The effect of concentration of chromic acid is considerable; with 50 g. CrO_3/l. a yield of 16% was obtained at 40° C. even with 6% H_2SO_4 at 20 amp./dm.^{2} With 200 g. CrO_3/l. the yield was only 6% under the same conditions. A previously assumed limit for good deposits of 1.2% H_2SO_4 with respect to CrO_3 was not confirmed. Addition of phosphoric acid produced bright deposits within definite concentrations but current efficiency was very low. Addition of boric acid produced bright deposits within wide limits but current efficiency was lower than for addition of H_2SO_4. Ammonium sulphate gave the same results as H_2SO_4 with regard to appearance of deposits, current density and amount of addition. Cr deposits produced at low temperatures are harder than those produced at higher temperatures, and deposits made with ammonium sulphate harder than those with H_2SO_4. Boric acid hardens the deposits, the hardness increasing with increased addition. A mixture of H_2SO_4 and boric acid produced greater hardness than H_2SO_4 alone; boric acid also reduced the harmful effect of too much H_2SO_4 and improved the action at too low content of H_2SO_4. Phosphoric acid reduced yield considerably even when present in small amounts; it should be avoided absolutely. Details of tests are described and results reproduced in tables. Ha (8d)

Production of Bright Electrolytic Deposits of Ni in Presence of Colloids (Sur l'Obtention de Dépôts Électrolytiques de Nickel Brillants en Présence de Colloïdes). MARCEL BALLAY. *Comptes Rendus,* Vol. 199, July 2, 1934, pages 60-62. Bright Ni deposits may be due to mineral or organic colloids in cathodic region added to solution or produced during electrolysis. Additions of chloride or boric acid to $NiSO_4$ solutions produce bright areas on cathode when variations in current density occur. The pH is just below that causing a visible precipitate of hydroxide or a basic salt of Ni. Cathodic area probably contains these compounds in a colloidal state. Organic compounds also give bright deposits, e.g. amidon, dextrine, gum arabic, agar agar, gelatin, egg albumin and casein. FHC (8d)

Chromium Plating Literature. XXV, XXVI, XXVII, XXVIII. L. H. DECKE. *Platers' Guide,* Vol. 20, May 1934, pages 17-19; June 1934, pages 17, 20-31; July 1934, pages 20-23; Aug. 1934, pages 25-26. General references. WHB (8d)

Electrolytic Deposition of Alloys. S. A. PLETNEV & V. V. KUZNETSOVA. *Tzvetnuie Metallui,* No. 5, June 1933, pages 51-56. Deposition of Ni-Co alloys of high Co content from sulphate solutions containing Ni and Co in the ratio of 15 to 1 was studied. Cast Ni anodes were used. The % Co in the deposited alloy was found to decrease with increasing pH, temperature and current density. Increase in the speed of rotation of the cathode resulted in higher Co concentration in the deposited alloy whereas agitation produced the opposite effect. Results indicated that Ni-Co alloys containing 30 to 50% Co can be easily deposited from solutions containing only the sulphates of the 2 metals. See also *Metals & Alloys,* Vol. 5, May 1934, page MA 204. BND (8d)

Electrodeposition of Fe-Ni Alloys (Zur Frage der elektrolytischen Abscheidung von Fe-Ni-Legierungen). F. MARSCHAK, D. STEPANOW & C. BELJAKOWA. *Zeitschrift für Elektrochemie,* Vol. 40, July 1934, pages 341-344. A study was made of deposits obtained under conditions of simultaneous electro deposition of Fe and Ni from mixture of simple salts in presence of colloids and conducting salts. Deposits were uniformly crystalline and adhered firmly to the base metal; thin deposits were elastic. Contrary to previous investigations it was found that, in electrolysis of long duration of solutions of low Ni concentration, the Ni content of the deposit increased; with high Ni concentration in the electrolyte, the Ni content of the deposit decreased in time. The Fe-Ni deposits were obtained at room temperature from a mixture of ferro and nickel sulphate solution to which ammonium sulphate, nickel chloride and glue were added. The anodes were Fe and Ni plates, the cathode a thin Fe sheet. The results are given in graphical form with photographs of sections. 8 references. Ha (8d)

Rhodium Plating. *Chemical Trade Journal & Chemical Engineer,* Vol. 93, Nov. 24, 1933, page 379. Brief report on paper by R. N. Atkinson, read at meeting of Electrodepositors Technical Society. Rh plating presents advantages of unusual hardness, high resistance to tarnish, corrosion and acids, and economy of material. See "Electrodeposition of Rhodium," *Metals & Alloys,* Vol. 5, June 1934, page MA 272. JN (8d)

Rhodium Plating, A New Progress in England (Rhodium Plattierung, ein neuer Fortschritt in England). *Die Metallbörse,* Vol. 24, Mar. 31, 1934, page 407. Advantages claimed for Rh coatings: corrosion-resistant, hard, non-tarnishing, not porous, identical in color with Ag and applicable to Ag, Ni, Cu, brass and bronze as basis. EF (8d)

Preparation of Silver Baths by Anodic Dissolution of Fine Silver (Die Herstellung von Silberbädern durch anodische Auflösung von Feinsilber). K. W. FROEHLICH. *Mitteilungen des Forschungsinstituts und Probieramts für Edelmetalle,* Vol. 8, May/June 1934, pages 15-20. A simple method to prepare baths for silver plating is described. Instead of dissolving fine Ag in HNO_3, precipitating as AgCl and dissolving in aqueous KCN solution, cast anodes of fine Ag are suspended in the CN bath. Cu or Ag strips surrounded by a porous porcelain cell serve as cathode; by weighing the anode before and after a certain time, the Ag content of the bath can be determined and adjusted accordingly. This method requires very little attention; as the current efficiency is about 70% the amperes only need be observed because 1 amp.-hr. dissolves about 3 g. Ag and this determines directly the time after which the required amount of Ag exists in the bath. Several anodes can be used provided they are not spaced too close together or near the wall. Heating of the bath above 40° C. must be avoided as otherwise the cyanide decomposes easily. Ha (8d)

The Application of the Fescol Process to Hydraulic Machinery. *Machinery,* London, Vol. 44, May 17, 1934, pages 184-185. Fescolizing is a cold (electrochemical) process, hence no distortion occurs and the base metal remains unaffected during the operation. Materials deposited by the process are: Ni, Cr, Cd, Cu, Pb. Field of application of the different deposited metals is touched upon. Discussion of examples to illustrate the advantages of Fescolizing when applied to hydraulic machinery. Procedure adopted to Fescolize new rams and building up worn rams is described. Kz (8d)

The Electro-deposition of Tin. *Chemical Trade Journal & Chemical Engineer.* Vol. 91, Oct. 28, 1932, page 397. Preparation and use of an acid electrolyte for tin plating, with sulphocresylic acid as a base, are discussed. JN (8d)

Cadmium-Plating Technology. *Chemical Trade Journal & Chemical Engineer.* Vol. 92, Apr. 7, 1933, pages 279-280. Several advantages are claimed for Cd plating over Zn, Ni, and Cu as a protective coating for iron and steel. Successful operation requires close chemical control; even then, deposits usually vary in thickness. A minimum of 400 mgms. Cd/sq. dm. is recommended. JN (8d)

Nickel Sulphate and Chloride. Quality Requirements for Plating Use. *Chemical Trade Journal & Chemical Engineer,* Vol. 91, Sept. 2, 1932, page 210. For reliable plating, Ni salts used should be neutral in reaction, contain less than 0.02% Fe and only small traces of Cu, and not over 0.25% total impurities. They should be free from dirt, excess moisture and small amounts of alkali. JN (8d)

Metallic Coatings other than Electroplating (8e)

Hot-dip Aluminum Coatings on Iron (Im Schmelzfluss hergestellte Aluminium-Überzüge auf Eisen). H. Röhrig. *Zeitschrift für Metallkunde*, Vol. 26, Apr. 1934, pages 87-90. Hot-dip Al coatings on Fe and steel are characterized by 4 layers: unchanged Fe, Fe-Al solid solutions, $FeAl_3$, a surface layer of Al with $FeAl_3$ interspersed. The ductility of such coatings increases with decreasing thickness of the brittle $FeAl_3$ layers. Fe must first be pickled to remove oxide layers which interfere with the diffusion of Al in Fe. Molten salts are best for this purpose; a list of these is given. The thickness of the $FeAl_3$ layer increases more rapidly with increasing bath temperature than with increasing immersion period. Cementite and graphite interfere somewhat; cementite is thrust ahead of the alloy layer, but graphite remains in place, the Al diffusing around it into the Fe matrix. These coatings have good resistance to sea-water corrosion and to high temperature oxidation. The tensile strength of heat-treated wire is reduced as expected from the temperature of dipping (720°-820°C). The best coatings are produced at low dipping temperatures and short immersions. Data are given on bending and torsional strength of hot-dipped wires. The addition of Si to the Al decreases the thickness of the $FeAl_3$ layer. Electrolytic coatings of Al on Fe are of little use for high temperature service because of blistering. The microstructure of Al hot-dipped coatings and their appearance after testing are shown in illustrations. RFM (8e)

The Preparation and Decoration of Aluminium and Its Alloys by Anodic Treatment. S. Wernick. *Industrial Chemist*, Vol. 10, May 1934, pages 179-183; June 1934, pages 231-233; July 1934, pages 265-267. A general survey of the field with review of early literature. 6 references. The Bengough-Stewart (chromic acid) process and the sulphuric acid process are described. A unique method for removal and study of the wide film by treating with mercuric chloride and mercury is given. In the second installment the properties of the film are discussed and in the third, the practical aspects of the process and details of operation. RAW (8e)

Aluminum Pigments and Lacquers (Aluminum färger och-lacker). Erik Hallström. *Teknisk Tidskrift* Vol. 64, July 21, 1934, pages 297-298. Gives the process of preparing aluminum for pigments and discusses uses, such as prevention of drying out of wood, reduction of evaporation losses in gasoline tanks, protection of metals against sulphurous fumes and other chemical attack including rusting. BHS (8e)

An Aluminum-Silicon Alloy as Heat and Rust Protective Coating of Cast Iron and Cast Steel (Eine Aluminium-Silizium Legierung als Wärme-und Rostschutzanstrich für Gusseisen und Stahlguss) *Zeitschrift für die gesamte Giessereipraxis*, Vol. 55, May 13, 1934, page 208. For Fe and steel castings that are subjected to temperatures above 150° C. a new paint coating is described distinguished by high stability at high temperatures. This coating is an Al-Si alloy developed from the 87% Al, 13% Si alloy in that it contains 50% of this alloy and 50% Si. Manufacturing method and application are outlined. Coating is marketed under trade name "Sigal." GN (8e)

Metallizing Process. *Industrial Finishing*, Vol. 9, June 1933, pages 30, 33. Describes metallizing unit and process for spraying molten metal on any solid base. Metal wire is fed automatically into a gas flame and melted into drops which are atomized to a fine spray by an air blast and driven onto the base material at a speed of 30,000 ft./min. to form a firm, even metal coating. JN (8e)

The Metals-Coating Process. Richard L. Binder. *Welding Engineer*, Vol. 19, June 1934, pages 17-21. Manifold uses of metal-spraying, for repairing surface defects, reconditioning stamp dies, covering glass with metals for use in electrical condensers, covering chemical apparatus with lead, spraying fittings with Zn, etc., are described; a table of detailed costs of typical salvaging jobs and savings made thereby is included. Ha (8e)

Non-Metallic Coatings (8f)

Aluminum Bronze Powder and Its Importance as Coating for Surface Protection (Aluminium bronze-Pulver und seine anstrichtechnische Bedeutung für den Oberflächenschutz). Fr. Kolke. *Oberflächentechnik*, Vol. 11, May 15, 1934, pages 113-114. A coat of Al-bronze powder is employed for (1) decoration (2) protection against corrosion, (3) heat-resisting coating materials, (4) reflectors. Decorative coatings are produced by simple brushing or by dusting the powder on a "tacky" layer of resin or paint, followed by polishing. Protection against corrosion is due to the overlapping of the leaf-like particles of the powder when put on a surface; the coating must contain at least 15 to 20% of Al powder, according to the fineness of powder and character of binding liquid. Al paints will stand temperatures up to 300°-400° C., sometimes up to 650° C., but the Al must be absolutely free from any traces of the fat such as is used in its preparation. The surfaces to be coated must be free of rust but no special primary coat need be employed. Al coating is used as reflector where heat effects are to be avoided, e.g., airplanes, search lights, etc. Al paints are now frequently used for the interior of breweries, chemical apparatus, ships, exposition halls, fans, decorative arts, and for the exterior of airplanes, tanks, cables. Ha (8f)

Painting Metal Products. Part I. L. E. Frost. *Industrial Finishing*, Vol. 10, Nov. 1933, pages 19-20; Part II, Dec. 1933, pages 16, 18-20. Rust spots may be removed by sand blasting, wire brushing, etc.; grease and dirt by petroleum solvents, carbon tetrachloride, lacquer thinner, toluene, and cleaning compounds dissolved in water. Paints in storage must be protected from the air. Paints in use must be well stirred, strained, if necessary, and properly thinned. Spraying methods for paint and the handling of lacquers are discussed in detail. JN (8f)

Bake Finishing Ovens and Auxiliary Equipment. *Industrial Finishing*, Vol. 9, Aug. 1933, pages 9-10,12. A discussion of finishing operations involving drying at high temperatures, with a description of a typical automobile factory installation including ovens, tanks, conveyors, blowers, air-conditioning and filtering equipment, temperature control, etc. JN (8f)

Dyed Aluminium. *Chemical Trade Journal & Chemical Engineer*, Vol. 94, Feb. 16, 1934, page 124. The surface of Al and Al alloys may be dyed any color by the new Gower-Alumilite process. The surface of the specimen, acting as anode in a H_2SO_4 bath, is first covered with a film of Al_2O_3. Then this is dyed in a bath containing organic or inorganic coloring matter and the effect made permanent and durable by immersions in a "sealing bath," details of which are not given. JN (8f)

Paints for Metalwork. *Chemical Trade Journal & Chemical Engineer*, Vol. 93, Nov. 17, 1933, pages 358-359. Resume of papers read at a symposium on "the functions of paint as a metal preservative" held jointly by the Oil and Color Chemists' Assoc. and the Chemical Engineering Group at the Institute of Chemistry, Nov. 9, 1933. JN (8f)

Artifoulings (Zur Frage des Schiffsbewuchses). M. Ragg. *Farbenzeitung*, Vol. 38, Dec. 23, 1933, pages 1757-1758. Controversy with W. Neu on the present state of protective paint coatings to seawater corrosion and maritime organism. See also "On the Influence of Dyeing of Antifoulings on the Growth of Maritime Organisms," *Metals & Alloys*, Vol. 4, Aug. 1933, page MA 271. EF (8f)

Enameling Small Articles with Whirling Machine. Leon J. Barrett. *Industrial Finishing*, Vol. 9, Mar. 1933, pages 11-12. A description of the process for coating batches of small metallic articles with a thin, even film of enamel by the use of the author's whirling or centrifugal machine. JN (8f)

Specifications for a System of Bituminous Pipe Line Protection. Ulric B. Bray & Frederick S. Scott. *Gas Age-Record*, Vol. 74, July 14, 1934, pages 33-37, 44-45. The Union Oil Co. of Calif., has developed the following system of pipe protection, for which they have reported excellent results. (1) The pipe is thoroughly cleaned by wire brushing and washing with kerosene in the case of new or used pipe in good condition, or by sand-blasting in the case of rusted used pipe. (2) Priming solution is brushed or sprayed on immediately after cleaning and allowed to dry thoroughly. (3) A hot sling coat of sealing asphalt is applied at a temperature of 375° F. (4) After allowing the sealing coat to cool for a few minutes or longer, the first coat of enamel is put on by sling application at a temperature of 425° F. (5) Immediately following the application of enamel, butt-jointed spiral wrapper is put on with sufficient tension to eliminate air pockets and squeeze out small amounts of enamel between the joints. (6) A flood coat of enamel is then applied over the wrapper. (7) For clay type or adobe soils, in most cases, a second layer of wrapper followed by enamel is applied. VVK (8f)

New Lacquers for Enameled Wire. H. Courtney Bryson. *The Industrial Chemist*, Vol. 10, Apr. 1934, pages 145-146. 15 references. The processes of drawing the wire, applying the lacquer, drying and winding are described. Methods of maintaining proper viscosity, tackiness and homogeneity are given. Some experiments on the use of ethyl and benzyl cellulose are given. RAW (8f)

Enameling Iron, Its Behavior in Enameling. Karl Kautz. *Metals & Alloys*, Vol. 5, Aug. 1934, pages 167-169. Enameling iron is 99.85% Fe carefully processed to meet customers' individual requirements as to physical properties, flatness, surface, and size of sheet. Surface textures and finish vary but rough cold-rolled finish made by using etched rolls, is most in demand. Routine control tests are made on grain size, Rockwell hardness ductility, (Olsen cupping test) and occasionally tensile strength. The properties vary within rather wide limits according to the user's requirements. Application and firing of enamel cost are described together with a discussion of the effect of firing on properties of iron. Theories for the adherence of enamel to iron are discussed, mechanical gripping action of irregularities on surface in enamel, adherence due to solution of oxide layer on iron in enamel, reduction of iron oxide to α ferrite which in form of dendrites "spike" the enamel on, and electrolytic theory whereby Fe replaced Co in silicates of enamel and Co precipitated in dendrites. WLC (8f)

Automobile Refinishing. H. R. Stewart. *Industrial Finishing*, Vol. 9, Mar. 1933, pages 14, 16, 18 and 19. Discusses cheaper methods of refinishing automobile bodies without too great reduction in quality and cites the precautions and conditions to be observed in these methods. JN (8f)

Finishing and Decorating Fire Fighting Apparatus. Frank A. Smith & Louis B. Kaser. *Industrial Finishing*, Vol. 9, May 1933, pages 7-9. Brief description of assembling, testing, inspecting, cleaning and paint shop finishing of modern motor driven fire trucks. JN (8f)

Black Finish on Metal Chemically. C. F. Scribner. *Industrial Finishing*, Vol. 9, Feb. 1933, pages 15-17. The chemical production of various black finishes on Cu, brass, bronze, Fe, steel, etc., is described. Durable black finishes may be produced by electrolysis in an alkaline arsenic bath, by combustion of a layer of oils, by chemical oxidation of the surface, and by the electro deposition and subsequent oxidation of a film of Cu or Cu and Ag. JN (8f)

Aluminum Paints Are Decorative. W. S. McArdle. *Industrial Finishing*, Vol. 9, July 1933, pages 27-28. Discusses use of Al paint for protection and decoration of industrial products such as mill work lumber and heavy shop and field machinery. JN (8f)

Coloring of Metals and Chemical Coatings (Ueber das Färben der Metalle und die chemischen Ueberzüge). H. Krause. *Die Metallbörse*, Vol. 24, Mar. 7, 1934, pages 290-291. Lecture before the Arbeitsgemeinschaft Deutscher Betriebsingenieure, Schwäbisch-Gmünd, Nov. 1933. A firmly adhering oxide layer on Fe is produced by alternating oxidation and reduction of 900°C. (650°C. lowest temperature). Gradual transitions in this cycle are rather essential. (1) Alternating cathodic and anodic treatment in NaOH or (2) treatment in Na nitrite produce the same effect. (3) Nitrates containing oxidizing agents such as permanganate, Na superoxide, etc., are also employed. The principal drawback of these treatments is due to the high temperatures involved which naturally change the physical properties. Immersion in hot concentrated Na lye containing an oxidizer produces a brown color on Fe objects. Swiss "black oxidation" is secured on Fe by covering the surface with a rust-promoting solution, followed by heating in a steam bath and finally coating with a film of paraffin or acid-free oil. Blue surface films are produced by Na-thiosulphate and Pb acetate. If a brilliant blue is desired this treatment is preceded by Ni plating. Black oxide films on Cu are produced by dipping into a solution of Cu and Ag nitrate and subsequently exposing the specimens at elevated temperature. H_2O_2 varies the shades of the surface film color. For coloring Mg, perchromates and permanganates are used. EF (8f)

Painting Galvanized Iron and Sheet Zinc. E. Perry. *Industrial Finishing*, Vol. 9, Jan. 1933, pages 11-12. Describes use of Cu salts for treating galvanized Fe, gives formulas for cleaning and etching metallic sheet Zn, and describes primers containing Portland cement for coating galvanized Fe linings used in refrigerators. JN (8f)

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

of METALS & ALLOYS, published monthly at East Stroudsburg, Pa., for October 1, 1934. State of Pennsylvania, County of Monroe, ss.

Before me, a notary public in and for the State and county of New York, personally appeared Richard Rimbach, who having been duly sworn according to law, deposes and says that he is the editor of the METALS & ALLOYS and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Reinhold Publishing Corp., New York, N. Y.; Editor, Richard Rimbach, New York, N. Y.; Managing Editor, Richard Rimbach, New York, N. Y.; Business Manager, Philip H. Hubbard, New York, N. Y.

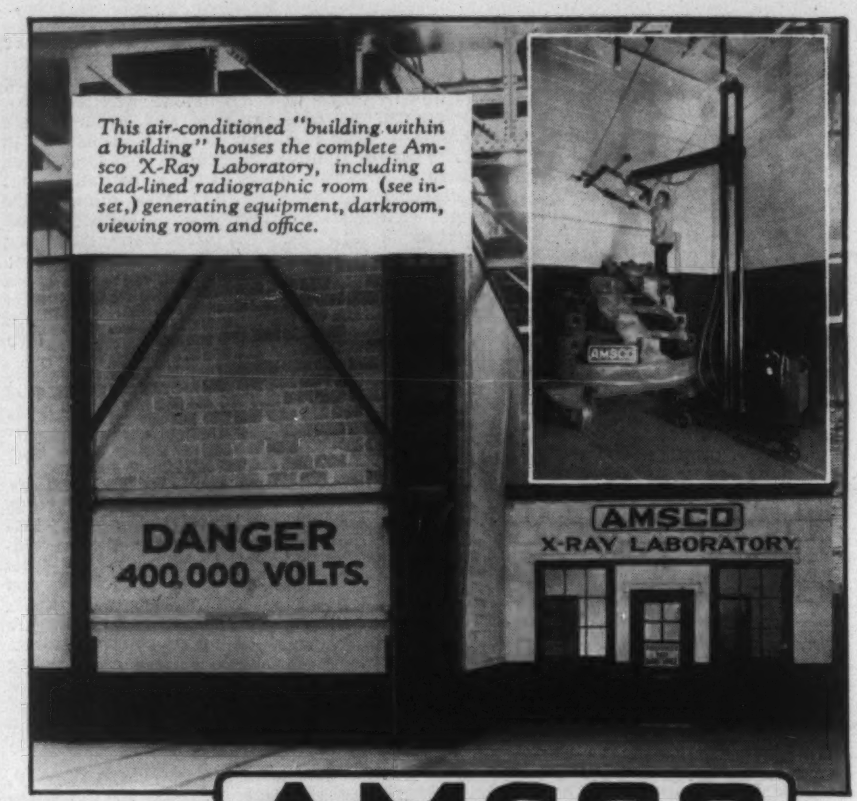
2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.) The Reinhold Publishing Corp., New York, N. Y.; R. W. Reinhold, New York, N. Y.; L. N. Thompson, New York, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

RICHARD RIMBACH, Editor.

Sworn to and subscribed before me this 17th day of September, 1934.

(Seal) CURVILLE C. ROBINSON, Notary Public
(My commission expires March 30, 1936.)



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TESTING (9)

Centralized Steel Research. *Industrial Chemist,* Vol. 10, July 1934, page 268. A note briefly describing the new central research laboratories of the United Steel Companies, Ltd., Sheffield, England. RAW (9)

Inspection & Defects, including X-Ray Inspection (9a)

C. S. BARRETT, SECTION EDITOR

Metallurgical Post-Mortem Examinations. G. E. HOWARTH. *Journal of the Institution of Production Engineers,* Vol. 13, Mar., 1934, pages 142-159. Includes discussion. The examination of fractured parts by the methods of chemical analysis, physical tests, macro- and micro-examination is briefly described and some common causes of failure of steel discussed. "Burnt" steel and fatigue fractures receive special consideration. JCC (9a)

Some Notes on Defects and Fractures. WILLIAM BENNETT. *Transactions Society of Naval Architects & Marine Engineers,* Vol. 41, 1933, pages 66-86. The nature of defects occurring in ingot and rolled material, fractures in ductile and brittle materials and the difference in their appearance which can serve as indication for type of stress and material, and fatigue phenomena are discussed with special application to problems in ship yards and engine shops. Many illustrations show the different type of fractures and defects; their connection with the constitution of metals and the method of calculating stresses in molecules and crystals is briefly explained; test methods are described. See also *Metals & Alloys,* Vol. 5, Sept. 1934, page MA 450 Ha (9a)

Defects in Railroad Rails. C. W. GENNET, JR. *Civil Engineering,* Vol. 4, May 1934, page 233-237. Problems raised by the occurrence of hidden defects in railway rails are discussed, and a description given of the Sperry detector car which detects and records defects through the distortion of a magnetic field produced in the rails. Vertical and horizontal split heads comprise 50% of total failures, are usually found in rails rolled from the top of an ingot, and are probably caused by segregation and unsoundness. Transverse fissures present a far greater, so far unsolved, problem. Impacts from heavy traffic, or stresses caused by thermal changes in manufacture are two explanations of their occurrence. JCC (9a)

Flakes in Forgings, Summary of Recent Discussions. H. H. ASHDOWN. *Metal Progress,* Vol. 26, Aug. 1934, pages 26-29. Summarizes recent discussions in *Metal Progress,* Vol. 24, Nov. 1933, pages 13-17, 62; Vol. 25, Feb. 1934, pages 38-39; Vol. 25, Mar. 1934, pages 163, 171; Vol. 25, May 1934, pages 36-40; see *Metals & Alloys,* Vol. 5, Aug. 1934, page MA 408. WLC (9a)

Improvements in the Schlieren Method of Photography. H. C. H. TOWNEND. *Journal of Scientific Instruments,* Vol. 11, June 1934, pages 184-187. A simple arrangement of light source for use in the Schlieren Method of photography which is of special use when a dark background is required. The image, instead of being shaded on one side and bright on the other, is bright on both sides. The Schlieren method is sometimes found useful in the study of metallic surfaces. RAW (9a)

Experiences in Micrographic Examination of Coal Specimens With Infra-Red Rays (Ertahrungen bei Mikroaufnahmen von Kohlendünnschliffen mit ultraroten Strahlen). FRITZ-ERDMANN KLINGNER. *Montanistische Rundschau,* Vol. XXVI, July 16, 1934, pages 1-4. Discusses this new method for studying the structure of coal. Conclusion regarding the formation temperature of the coal may be drawn from the appearance and the structure of the rosin which is easily brought out in photographing with infra-red rays. BHS (9a)

X-Ray Exposure Charts for Steel. HERBERT R. ISENBURGER. *American Society for Metals Preprint* No. 22, 1934, 5 pages. Charts are shown for the rapid determination of proper exposure time based upon the actual density of materials and greatest thickness to be penetrated. WLC (9a)

Testing Materials With X-Rays (Materialprövning med Röntgenstraaler). V. FURUHEIM. *Teknisk Ukeblad,* Vol. 81, July 26, 1934, pages 365-368. Gives the construction and operation of vacuum tubes. Describes a portable apparatus operating at a maximum of 200,000 volts. The apparatus is equipped with 8.5 m. long Siemens & Halske high-tension cable insuring a high degree of safety; the transformer, which is the heaviest part of the equipment, is divided into two parts, each weighing about 70 kg. Very compact arrangement of the tubes makes it possible to bring the apparatus through small openings, as for instance the manhole of a boiler. It may be used for examining steel sheets up to 80 mm. thick. A general discussion of procedure and manipulation in examining castings and welds is included. BHS (9a)

Radiographic Methods for Testing Welds. *Journal of Commerce (Shipbuilding & Engineering Edition)* July 12, 1934, page 1. A discussion of X-ray methods of testing welds indicates that unsatisfactory results may be obtained due to irregularities in the thickness of the weld metal rendering accurate diagnosis of photographs difficult, and to the fact that certain types of defects are difficult to detect. The commercial aspect of radiographic methods is also considered and compared with practical workshop methods, which are considered to be satisfactory for general industrial purposes. JWD (9a)

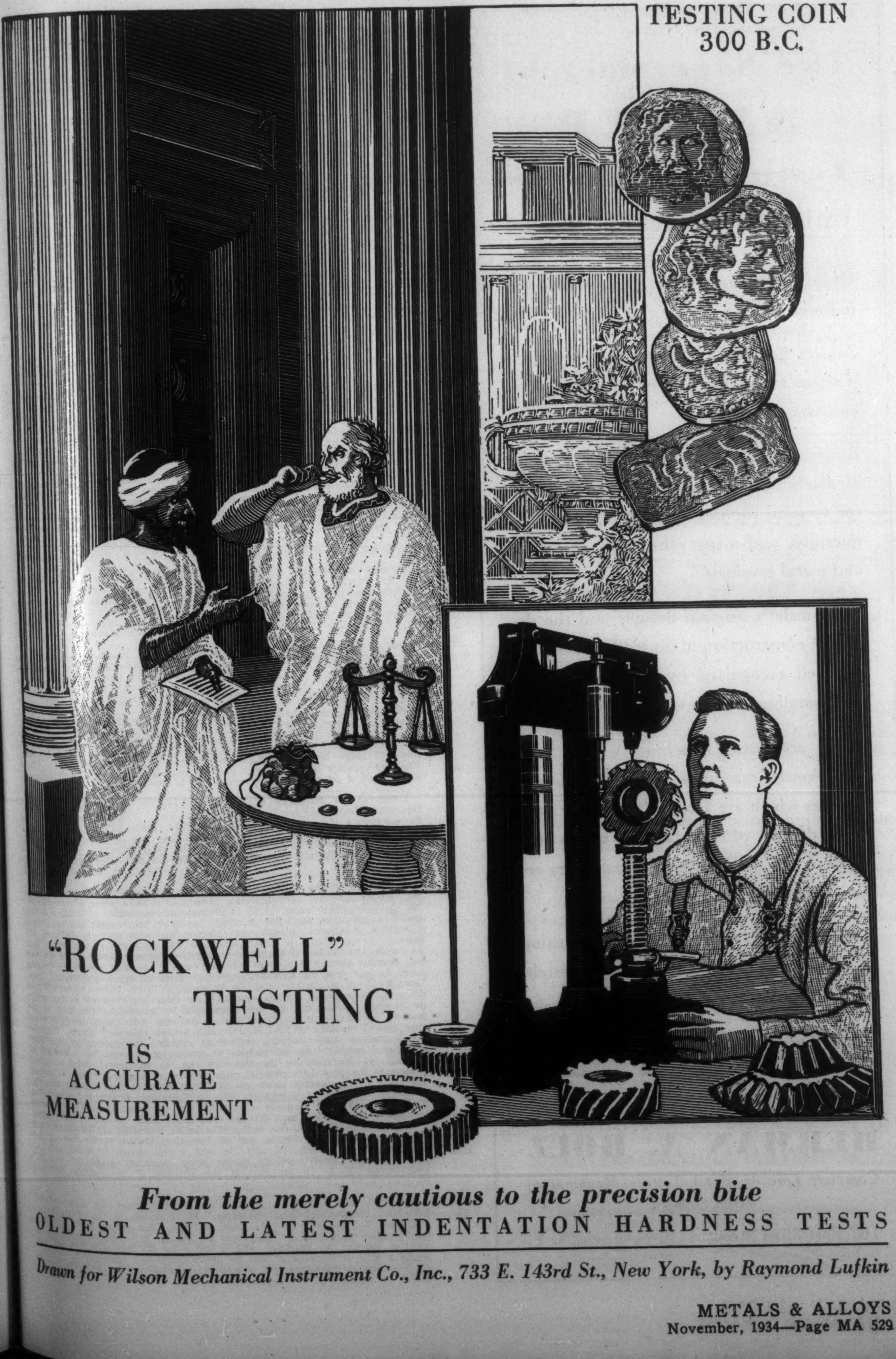
Present Status of Inspecting Important Metallic Materials with X-Rays (Über dem heutigen Stand der Untersuchung wichtiger metallischer Werkstoffe durch Rontgenstrahlen). FRITZ BENNIGSON. *Die Metallbörse,* Vol. 24, Mar. 17, 1934, pages 341-343; Mar. 24, 1934, pages 373-374. The latest radiological equipment on the German market and the scope of utilization are discussed and illustrated. The use of X-ray films coated on both sides and of intensifying screens are emphasized. The latter cut down exposure times by 20-30 times. A special "Rubra foil combination" again doubles these short exposure times yet gives an improved sharpness of the image. In Fe samples up to 12-15 mm. thickness, inhomogeneities can be detected by X-rays down to 7% of the total thickness of the work. The same holds for Cu but only up to 8 mm. while with Al, defects of 5% of the total thickness of the object can be recognized up to 70 mm. max. The sensitivity drops with increasing thicknesses of the work and with increasing tube voltages. EF (9a)

Advantages of Radiographic Inspection to Foundrymen. HERBERT R. ISENBURGER. *Transactions American Foundrymen's Association,* Vol. 5, Apr. 1934, pages 502-514. Discussion together with exposure and cost charts for the examination of steel castings give a comparison of the relative economies between X-ray equipment and radium. X-ray exposure technique and foundry practice are discussed. Radiographic inspection should be a worthwhile tool for ferrous and non-ferrous foundry work as well as a sales factor. CEJ (9a)

Physical & Mechanical Testing (9b)

W. A. TUCKER, SECTION EDITOR

A Method of Micro-mechanical Study of the Development of Strains in Metals when Statically Stressed. E. SHUMOVSKII, K. KLIMOV & A. ORLOV. *Stal,* Vol. 4, Feb.-Mar., 1934, pages 48-60. Specimens of steel 3 mm. thick and 5 mm wide were polished, micrographically examined, and stressed; then re-polished and re-examined. The deformation of grains, and the development of slip bands and of cracks were studied. HWR (9b)



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The Brinell Hardness of Bearing Metals (Die Brinellhärte von Lagermetallen). A. VÄTH. *Zeitschrift für Metallkunde,* Vol. 26, Apr. 1934, pages 83-86. The relationships between Brinell impression diameter, time of loading, and value of load were studied for three high-tin and four high-lead bearing metal compositions. These are given in tables and graphs. The Brinell hardness number is greatly dependent upon time of loading and the amount of load; short loading times give greater hardness values than long. The hardness value increases with increasing load to a maximum value and then decreases. It is suggested that this maximum hardness should be used in testing. The loading of the ball should be chosen so that the diameter of the impression is from 1/4 to 2/3 of the ball diameter. RFM (9b)

The Pressure-draw Diagram as a Characterization of the Deep-drawing Process. New Experiments with the Erichsen Sheet Tester (Das Druck-Ziehweg-Schaubild als charakteristisches Kennzeichen des Tiefzieh-Vorganges. Neue Versuche mit dem Blechprüfgerät nach Erichsen). A. H. F. GOEDERITZ. *Zeitschrift für Metallkunde,* Vol. 26, Mar. 1934, pages 49-55. Diagrams of plunger pressure versus plunger displacement (a deep-drawing stress-strain diagram) are given for disks of strip steel, 63:27 brass, 83.5:16.5 Ag-Cu alloy, electrolytic Cu strip, Zn sheet, and Al sheet; the effect of variations in disk diameter and thickness, and in annular clearance, plunger diameter and hold-down pressure was studied. It is shown that the form of curve is the same for all materials, rising first to a pronounced maximum, then decreasing and finally rising to a less marked maximum just before fracture. For each material there is an especially favorable annular clearance between plunger and die; with greater or lesser clearances the maximum plunger pressure becomes greater thus leading to early fracture, though at the proper clearance no difficulty in deep drawing is encountered; this is more clearly evident in materials of high strength properties, like steel, than in those of low, like Al. A deep drawing material may thus be classified according to the highest plunger pressure (corresponding to maximum load in a tensile stress-strain diagram), the maximum plunger displacement (corresponding to tensile elongation), the total expended work—the integrated area of the diagram, or the expended work per mm. of draw. These data are shown on a series of diagrams and in a table. RFM (9b)

The Status of the Impact Test (Etat actuel de l'essai de fragilite des metaux). P. DEJEAN & S. GERSZONOWICZ. Dunod, 92 Rue Bonaparte, Paris, France, 1934. Paper, 6½ x 10 inches, 103 pages. Price 20 Fr.

A correlated abstract, covering 47 references, chiefly French and German, discussing the variables that may affect the notched bar impact test. While the title refers to metals in general, practically all the examples relate to steel. The effects of temperature, size of specimen, grain size, etc., are brought out, chiefly in relation to Charpy bars. There is little new information in the resumé and it is written from the testing materials point of view rather than the metallurgical one, though considerable metallurgical information is included. No reference is made to any articles in the Proceedings of the American Society for Testing Materials. The writers make a plea for standardization, themselves preferring the Charpy bar 10 x 10 mm. x 55 mm. long, 40 mm. between supports, with a 5 mm. deep keyhole notch using a drilled hole 2 mm. diam. The pamphlet has a summary in Esperanto. Although the literature is by no means completely covered, the summary is a useful one. H. W. Gillett (9b)—B—

Relation of Hardness of Non-ferrous Metals to Strength and Workability. J. R. TOWNSEND. *Metal Progress,* Vol. 26, Aug. 1934, pages 35-40. Proposes the use of the load required to produce unit penetration, measured under load, of a unit penetrator as the criterion of hardness. Such hardness numbers will include both the elastic and plastic deformation and they bear a uniform relation to tensile strength of non-ferrous materials studied, 18 in number. WLC (9b)

Various Tests for Cast Iron. R. S. MACPHERRAN. Part of Symposium, Tests and Specifications for Cast Iron. *Transactions, American Foundrymen's Association,* Vol. 5, Apr. 1934, pages 562-564. Brief discussions are given of various tests for cast iron. The transverse test, tensile test, hardness test, impact test, chill test, fatigue test and compression test are mentioned. CEJ (9b)

Factors of Mechanism of Testing. JAS. T. MACKENZIE. Part of Symposium, Tests and Specifications for Cast Iron. *Transactions, American Foundrymen's Association,* Vol. 5, Apr. 1934, pages 569-572. Points of special importance in securing accurate data are discussed briefly. Transverse test should be made slowly to insure accuracy. Reliable measurement of deflection difficult. Proper alignment necessary in tensile test. Hardness best determined by the Brinell test, using a ball of 10 mm. diameter with a load of 3000 kg. CEJ (9b)

Factors in the Production of Test Bars. JAS. T. MACKENZIE. Part of Symposium, Tests and Specifications for Cast Iron. *Transactions, American Foundrymen's Association,* Vol. 5, Apr. 1934, pages 573-574. Requirements of good molding and pouring practice for test bars are as essential as for any other casting of similar shape and section. The proper selection of material insuring good condition of surface with clean metal and a suitable pouring temperature are important. CEJ (9b)

The Meaning of the Transverse Test of Cast Iron to the Designing Engineer. JAS. T. MACKENZIE. *Transactions, American Foundrymen's Association,* Vol. 5, June 1934, pages 35-55. Simplicity of conversion of transverse test results to unit values applicable to design has never been taught the foundrymen or engineer in America although some progress has been made in Germany and England. As an estimate of surface conditions, the transverse test is better than the tensile test because it retains the relatively stronger outer fibers of the test bar. Accurate plotting of the load-deflection curve is necessary. Since the bending curves for cast iron are continuous curves no parts of which are straight lines, Young's modulus of elasticity must be an empirical figure. When calculated from the actual deflection at stresses comparable to those contemplated in the design the resultant modulus may be used confidently for calculating the bend of the member. Moduli of rupture are calculated from the well known formulas which when applied to standard A.S.T.M. test bars become extremely simple. Information is given to enable designing engineer to calculate the strength of practically any shaped member from the modulus of rupture of a round bar. Modulus of elasticity, as determined by the transverse test, in the useful range of stress, is close to the same figure obtained from tension or compression test. Curvature and shape of the bending curves are related directly to the damping capacity, permanent set or plastic deformation, and machineability through the interrelation of Young's modulus of elasticity. Toughness may be estimated also in terms of resilience which is the area under the stress-strain curve divided by the volume of the specimen. The transverse test gives a better indication of the strength and stiffness of large sections because bars of dimensions similar to the sections may be tested. In the tensile test only the core of the section is tested and that section generally shows especially in the softer machinery grades of cast iron approximately 60 to 70 per cent of the strength of the outside materials. CEJ (9b)

Experiments with Impact Testing Apparatus for Compressed Air (Versuche mit Prüfgeräten für Druckluft-Schlagwerkzeuge). H. PRESSER & E. SCHLOBACH. *Glückauf,* Vol. 70, June 2, 1934, pages 497-504. The various types of impact testing apparatus operated by compressed air do not give results which can be compared directly. An instrument with a spring for the impact action has been developed which is recommended both for measurements and especially for calibrating compressed air instruments. It is described in detail and is useful for tests in mining, for metallurgical and non-metallic specimens. Ha (9b)

A Mechanical Testing Machine. R. C. GALE. *Journal of Scientific Instruments,* Vol. 11, July 1934, pages 209-214. A mechanical testing machine is described which is suitable for testing metals or other solid materials by tension, compression, indentation, bending, etc. The test pieces are held in readily interchangeable shackles and grips attached to movable members of the machine. Stress is applied to the test piece by the rotation of a capstan-headed screw, and is balanced and measured by the compression of a stiff helical spring. RAW (9b)

Appraisal of Materials by their Damping Properties (Die Qualifikation der Werkstoffe mit Hilfe der Werkstoffdämpfung). O. FÖPPL. *Mitteilungen des Wöhler-Instituts,* Braunschweig, in No. 18, 1934, separately paged, 8 pages. Föppl complains that his arguments in favor of making crankshafts for internal combustion engines from materials with high damping power, have not received the attention they deserve. (The Ford crankshaft should please him.) He states that the damping of a material depends upon the plastic constituent of deformation. Purely elastic materials are free from damping, and local stresses cannot be readily relieved by local flow. Notches and other stress raisers are therefore more harmful in materials of low damping and high elasticity than in those of opposite properties. Large elongation in static test is not helpful, it is the plasticity far below the breaking stress that counts. Thus the degree of damping that obtains below the endurance limit is the important factor in fatigue. The mass which is affected by a local stress-peak is a fundamental property of a material. In a single crystal the effect of a notch depends on how the notch is oriented with regard to the crystal lattice. Crystal size has an effect on notch-tenderness. If the mass disturbed by the notch is large compared to the crystal size, the damping curve will evaluate notch-tenderness. HWG (9b)

Symposium, Tests and Specifications for Cast Iron. AMERICAN FOUNDRYMEN'S ASSOCIATION. *Transactions American Foundrymen's Association,* Vol. 5, April, 1934, pages 558-591. Symposium consists of eight articles discussing tests and specifications for cast iron. CEJ (9b)

Relationship of A. S. T. M. and A. F. A. in the Development of Tests and Specifications. H. BORNSTEIN. Part of Symposium, Tests and Specifications for Cast Iron. *Transactions, American Foundrymen's Association,* Vol. 5, April 1934, pages 558-559. A. F. A. has encouraged research in respect to manufacture and the A. S. T. M. has devoted itself to testing and specifications of cast iron in A. S. T. M. committee A-3 on Cast Iron. Close coöperation on problems has prevented duplication of effort and yielded mutual benefit. CEJ (9b)

Significance of Testing Cast Iron and Limitations of Testing. H. BORNSTEIN. Part of Symposium, Tests and Specifications for Cast Iron. *Transactions American Foundrymen's Association,* Vol. 5, Apr. 1934, pages 560-561. Type of test should be selected to show value of casting for its particular service. Chemical analysis valuable for control while physical tests are more valuable to the consumer. Best test is a service test as physical test results because of limitations are only indicative at the best. CEJ (9b)

A. S. T. M. Specification A48-32T. JOHN W. BOLTON. Part of Symposium, Tests and Specifications for Cast Iron. *Transactions, American Foundrymen's Association,* Vol. 5, Apr. 1934, pages 586-591. Factors which have influenced the evolution of the specification are reviewed. The present specification is an attempt on the part of producers and consumers on A. S. T. M. Committee A-3 on Cast Iron to evolve a sound and equitable specification. Cast irons are classified by tensile strengths in bars which approximate casting sections. Chemical analysis left to the foundryman, who supplies material to meet phyical requirements. CEJ (9b)

Wear Tests and Value of Hardness Testing for Control of Product. A. L. BOEGEHOLD. Part of Symposium, Tests and Specifications for Cast Iron. *Transactions, American Foundrymen's Association,* Vol. 5, Apr. 1934, pages 575-586. Various types of wear tests which have been conducted by investigators in the past are described. Methods are classified into service tests, accelerated service tests, laboratory tests simulating service conditions and arbitrary laboratory tests. General conclusions indicate that increased hardness or a hard constituent in iron results in decreased wear. Hardness test is a satisfactory method for control and inspection of cast iron articles. 28 references. CEJ (9b)

Thread Tolerances and Strength of Bolted Joints (Gewindetoleranzen und Festigkeit von Schraubenverbindungen) G. BERNDT. *Zeitschrift Verein deutscher Ingenieure,* Vol. 78, June 2, 1934, pages 661-662. Previous tensile, impact and endurance tests with bolts of 1" diam. had shown that tolerances in thread have no effect on the test results; this is now also confirmed for endurance impact tensile stress with a superimposed stress of 6500 kg. Tests were made on a pendulum impact machine with bolts of 350 and 290 mm. total length and 60 mm. length of thread. Ha (9b)

Fatigue Testing (9c)

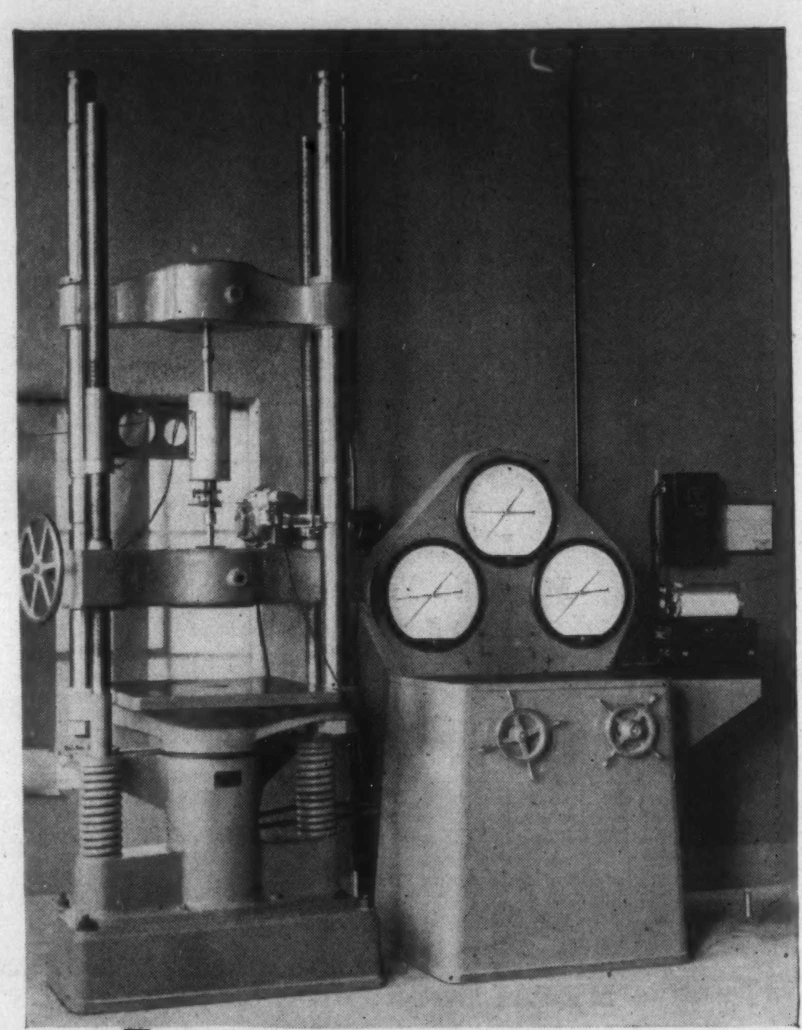
H. F. MOORE, SECTION EDITOR

The abstracts appearing under this heading are prepared in co-operation with the A.S.T.M. Research Committee on Fatigue of Metals.

Comparison of the Tensile Strength of a Riveted and Welded Construction in Fatigue Testing. (Vergleich der Festigkeit einer genieteten und einer geschweissten Konstruktion bei Dauerbeanspruchung). KUHL. *Die Elektroschweissung,* Vol. 5, June 1934, pages 114-116. Report of investigations by Paton, Buschtedt & Tschudnobsky at Ukranian Academy of Science. Investigations carried on by Bernhard (*Zeitschrift Verein deutscher Ingenieure,* Vol. 73, 1929, page 1675) on the fatigue properties of welded constructions that resulted in a very low resistivity against fatigue loads of welded constructions as compared with a corresponding riveted one led to these investigations on a riveted and a welded bridge construction. The general constructional arrangement is first described. The results of vibration tests are summarized. To destroy the riveted bridge construction 35000 more vibration cycles were required than to destroy the welded one. However 30000 cycles were sufficient to weaken the junction points of the riveted bridge whereas the welded joints endured 7 times this number of cycles without damage. In the welded construction failure occurred in the base material. all of the weld joints remained unimpaired. Authors, therefore, advise to prefer welded construction because riveted joints easily relax in dynamically loading, whereas in welded constructions deformation occurs much later. Reviewer cautions against these far reaching conclusions of the Russian authors whose opinions contradict opinions prevailing in Germany. Checking of these results by fatigue tests on suitable constructions is advised. (Note by HFM: The abstractor's caution against complete acceptance of the conclusions seems especially justified in view of the use of relatively few cycles in testing and the use of numbers of cycles of stress as a criterion of fatigue strength.) GN (9c)

Corrosion Fatigue. *Commonwealth Engineer,* Vol. 21, Jan. 1, 1934, page 157. Reviews experiments of A. J. Gould at Cambridge University on corrosion fatigue of a .15 C, .59 Mn, .21 Si steel. The following fatigue limits measured in lbs./in.^{2} x 10^7 reversals were established: air = 39.400, distilled water = 21.400, KCl solution = 10.000. The corrosion inhibiting effect of Na_2CO_3 was found to be rather pronounced. 0.16% Na_2CO_3 added to distilled water raised the corrosion fatigue limit to 40.000 lbs./in.^{2} x 10^7 reversals which is believed to be the maximum fatigue strength possible of attainment. WH (9c)

Fatigue and Corrosion (Ermüdung und Korrosion). K. LAUTE. *Oberflächentechnik,* Vol. 10, Dec. 19, 1933, page 281. See *Metals & Alloys* Vol. 5, May 1934, page MA 210. Ha (9c)



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The Fatigue Strength of Lead (Die Schwingungsfestigkeit des Bleies). W. Stockmeyer. *Zeitschrift für Metallkunde,* Vol. 26, Apr. 1934, page 93. The addition of 1% Sb increases the resistance of Pb pipe to corrosion fatigue. RFM (9c)

The Torsional Endurance Properties of Specimens with Keyways and the Increase in Fatigue Resistance from Working the Surface (Die Drehwechselfestigkeit genuteter Stabe und die Erhöhung der Dauerhaltbarkeit durch Oberflächendrücken). W. Meyer. *Mitteilungen des Wöhler-Instituts,* Braunschweig, No. 18, 1934, 73 pages. A study of the endurance in torsion of shafts bearing keyways, in 4 carbon steels, 0.14% C, 61000 lbs./in.^{2} tensile strength; 0.33% C .90% Mn, 80000; 0.33% C .58% Mn 93000; and 0.63% C 125000. All the steels had 20 to 26% elongation. Keyways cut the endurance by 22 to 47½%, the reduction increasing with the tensile strength. Flattening the top of the keyway so as to avoid a sharp edge diminished the loss of endurance by some 10% in the softer steels, but did not help with the harder ones. Failure started at the base of the keyway in the harder steels. Cold working the keyway bottom and sides with a pressure roller did not help and it was necessary to cold work with tools driven by an air hammer. While the results showed much scatter some of the specimens showed improvement of the order of 20% due to cold working. These tests were made on keywayed shafts with nothing keyed onto the shaft. Further experiments with full assemblies are in progress. The preparation and behavior of each specimen tested are described in detail. Further work along previous lines with cold worked circumferential grooves on torsion fatigue specimens showed slight improvement due to cold working. HWG (9c)

Magnetic Testing (9d)

L. REID, SECTION EDITOR

Non-Destructive Material and Weld Testing with Particular Reference to Magnetic Methods (Zerstörungsfreie Werkstoff-und Schweissnahtprüfung unter besonderer Berücksichtigung Magnetischer Verfahren) E. Kuhn. *Die Wärme,* Vol. 57, Mar. 31, 1934, page 213. Magnetic methods are usually handicapped in their application due to the large magnets involved. The method of Pfaffenberger & Dahl rotates the specimen, for instance sheets for deep drawing, between 2 magnetic poles and reveals the fiber structure of the sheets. Fe filings are utilized by other experimenters for detecting inhomogeneities, for instance in welds, by discontinuities in the flux lines of a magnetic field. In Italy Fe dust is suspended in oil. A new testing method has been brought out by the Allgemeine Elektrizitätsgesellschaft coöperating with the I. G. Farbenindustrie. Current impulses are induced into the specimen which is or has been magnetized and defects are found acoustically by earphones. EF (9d)

METALLOGRAPHY (10)

J. S. MARSH, SECTION EDITOR

The Interpretation of a Photomicrograph. Josiah W. Jones. *Iron & Steel Industry,* Vol. 7, Dec. 1933, pages 87-93. Paper presented at a meeting of the Midland Metallurgical Societies in Birmingham, Nov. 1933. CEJ (10)

Bakelite as an Embedding Agent for Hard Materials for Preparing Micrographic Sections of Fine-Grained Material (Bakelit als Einbettungsmittel für harte Stoffe zur Herstellung von Feinkornschliffen). L. Kremser. *Glückauf,* Vol. 70, June 12, 1934, pages 553-554. A mixture of bakelite in powdered form and the dust (metal, glass) to be examined is compressed in an electrically heated mold at 180° C. under 400 kg./cm.^{2} pressure or higher; the procedure is described in full. The specimen is ground on a carborundum wheel and polished with magnesia or alumina on a glass disc. The specimen remains entirely plane and does not warp. Several examples are shown. Ha (10)

A Study of Crystal Structure and its Application. Wheeler P. Davey. McGraw-Hill Book Company, New York, 1934. Cloth, 6 x 9¼ inches, 695 pages. Price $7.50.

This book is one of the "International Series in Physics" and has been written as a text for graduate students, not as an encyclopedia of theory or results. Much space is given to the derivation of equations and to specific examples of crystal structure determination which are explained in detail, step by step. References to original papers are not intended to be complete but appear to be well chosen for the purpose. Many of the chapters in this book will meet with wide approval; some will be accepted less heartily, and a few may be relied upon to stir up disapproval.

Much of the book follows closely, though with additions. Professor Davey's well known series of articles in the General Electric Review (1924-1926),—particularly the introductory material and the chapters on the Laué, Bragg, and powder methods. As in that series, the author has used the method of Hull's 1917 paper to present the origin of the diffraction pattern, explaining absent reflections by the "periodicity of planes." Many readers will feel that the structure amplitude equation, which is treated later in the book, should be used for this task, since it must be resorted to for intensity calculations in all but the simplest cases. The treatment of the powder method adequately covers the graphical methods of solution, but slights recent precision lattice constant methods. Stereographic and gnomonic projections are presented through the medium of F. E. Wright's equations. W. P. Jesse has contributed a fine chapter on the oscillating crystal method. There are some eighty pages given to the theory of space groups and its application, with symmetry data drawn from Wyckoff's "Analytical Expression of the Theory of Space Groups" and with detailed examples of the use of the theory in the determination of crystal structure; Astbury and Yardley's space group tables are appended with correlations between the different systems of nomenclature. There is a detailed treatment of the atomic structure factor, including examples of its application by Bragg and his collaborators to the solution of the structure of diopside and topaz. There are also chapters on the refraction of light from crystals and on X-ray diffraction from amorphous materials (liquids, gases, gels).

As to the result of crystal analysis, Prof. Davey has elected to discuss at length those subjects in which he has been most interested rather than to give a general, balanced survey of the whole field as is done by W. L. Bragg in "The Crystalline State, Vol. I, A General Survey," or a listing of structures that have been determined, as in Wyckoff's "The Structure of Crystals," or on the other hand a catalogue of practical applications such as Clark's "Applied X-rays." Chapters on atomic shapes and sizes and on lattice energetics are enlarged from the General Electric Review articles; a chapter is devoted to types of chemical combinations in crystals, molecular symmetry, and organic compounds; the author's 1933 A. S. S. T. paper on the mechanism of crystal growth and its consequences appears as well as the ideas in Phelps and Davey's 1932 A. I. M. E. paper on solid solutions. The speculative nature of these papers is admitted, but the author says he includes them to develop in his students critical—though "sometimes unorthodox"—viewpoint.

For the metallurgists there is a chapter devoted to some of the methods for determining the orientation of single crystals and the preferred orientation of polycrystalline materials, including a section on the pole figure method written by M. L. Fuller, who has also contributed an appendix on X-ray equipment and its operation. Charles S. Barrett. (10) -B-

A New Objective for Metallurgy. H. Wrighton. *Journal Royal Microscopic Society.* Series III, Vol. 53, Part 4, Dec. 1933, pages 328-329. Monobromnaphthalene immersion objective made by Beck Co., has N. A. of 1.60, focal length 2.25 mm and is calculated for the wave length 4359 which can be obtained with a Pointolite lamp and 50 L Wratten filter. It has excellent definition almost free from glare. High power eyepieces can be used. JDG (10)

The Recrystallization of Silicon Alloyed Soft Iron (Die Rekristallisation siliziumlegierten Weicheisens). A. Wimmer & P. Werthebach. *Stahl und Eisen,* Vol. 54, April 19, 1934, pages 385-392. Grain growth after cold work and annealing was studied in four types of transformer sheet with about 0.02% C and 1 to 4% Si. The samples were cold rolled to deformations of from 0 to 20%. The recrystallization temperature was lower the greater the deformation. The largest grains were obtained in a 1.9% Si steel cold worked 3 to 4% and annealed at 850 to 900° C. With increasing Si content larger grains were obtained after lighter deformations. Raising the recrystallization temperature had little effect in increasing the grain size. By cold work and recrystallization Si steel sheet can be obtained with grains averaging more than 1 sq. cm. in area. With such large grained sheet the watt losses were considerably reduced. SE (10)

Technologic Applications of X-Ray Crystal Structure Studies (Anwendung von Röntgen—Feinbauuntersuchungen bei technischen Aufgaben). F. Wever. *Archiv für das Eisenhüttenwesen,* Vol. 7, Mar. 1934, pages 527-530. A correlated abstract dealing mainly with the changes in crystal structure produced by cold working and the determination of internal stresses by means of X-rays. 17 references. SE (10)

Structure of Silver Amalgams (Struktur des Silberamalgams). A. Weryha. *Zeitschrift für Kristallographie,* Vol. 86, Nov. 1933, pages 335-559. Ag amalgams were prepared by dipping Hg drops into a weak solution of $AgNO_3$. Chemical analysis and X-ray determinations revealed the formation of the compound Ag_3Hg_4. In spite of the apparent hexagonal structure of the crystals, this amalgam actually belongs to the cubic system. On a Ag wire dipped into Hg, the same amalgam was found. EF (10)

Alloys of Iron, Manganese and Carbon—Part VII. Influence of Carbon on 13% Manganese Alloys. Cyril Wells & Francis M. Walters, Jr., *Transactions American Society for Steel Treating,* Vol. 21, Sept. 1933, pages 830-845. 13% Mn section of the Fe-C-Mn diagram has been determined. After separation of carbides by cold working and soaking, gamma remaining transformed principally to epsilon on cooling. Increasing C decreases amount of gamma phase decomposed below soaking temperatures. WLC (10)

Equilibrium Diagram of Copper-rich Copper-tin-zinc Alloys. Keiji Yamaguchi & Kozo Nakamura. *Tetsu to Hagane,* Vol. 20. Jan. 25, 1934, pages 34-42 (In Japanese); *Bulletin of Institute of Physical & Chemical Research,* Vol. 11, Dec. 1, 1933, pages 1130-1352. (In Japanese). The equilibrium diagram of Cu-Sn-Zn system in the composition range up to 40% Sn and 50% Zn was studied by thermal analysis and structure examination. In the Cu-Sn system, the following new facts are found: The change taking place at about 580° in alloys from 15 to 20% Sn is attributed to the eutectoid reaction, $\beta \longrightarrow \alpha+\gamma$, as reported by Bauer and Vollenbruck, which is also deduced from the study of the ternary system. In alloys with about 34% Sn, an intermediate phase ϵ is formed peritectically at 644° by the reaction, $\gamma+\eta$ (Cu_3Sn)$\longrightarrow\epsilon$, as proposed by Hamasumi and Nishigori; this ϵ changes to δ (Cu_4Sn) and $\delta+\eta$ on cooling by the reactions, $\gamma+\epsilon\longrightarrow\delta$ and $\epsilon\longrightarrow\delta+\eta$, respectively. In the Cu-Sn-Zn system, there exists no phase of ternary compound, the α- and β- phases in Cu-Sn and Cu-Zn systems forming respective continuous solid solutions. The change, $\beta\longrightarrow\beta^1$, in Cu-Zn system occurs in a narrow composition range of the ternary system on which, however, not so much is studied. A projectional, 7 sectional, and 3 isothermal diagrams are given. ST (10)

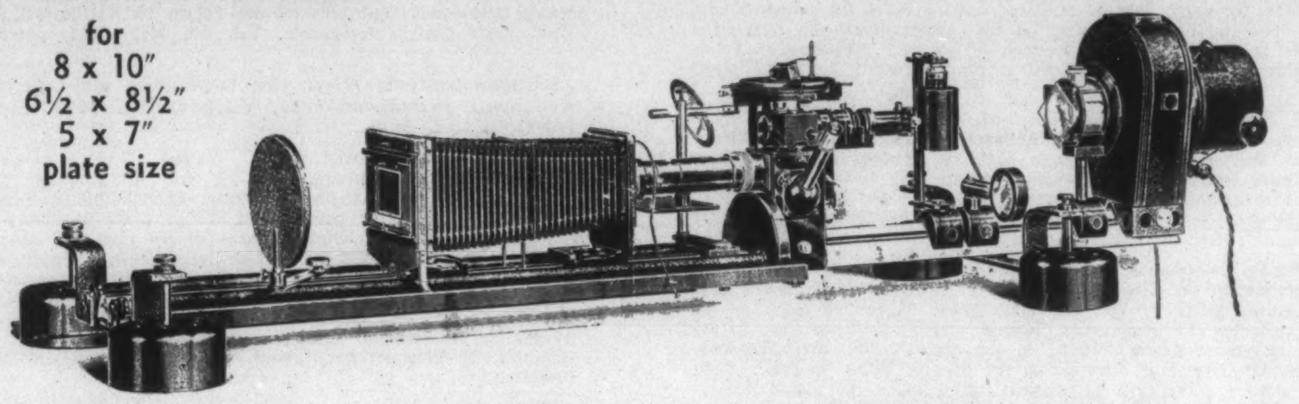
Crystal Structure as a Guide in the Working of Magnesium Alloys. W. Schmidt translated by G. E. Doan. *Metals & Alloys,* Vol. 5, July 1934, pages 149-153. Reviews practical applications of X-ray crystal studies to the improvement of commercial technique of working Elektron, 87-95% Mg, 4-10% Cu, 1-3% Zn. See also "Crystal Structure and Forming as Exemplified in Elektron Metal," *Metals & Alloys,* Vol. 5, June 1934, page MA 282. WLC (10)

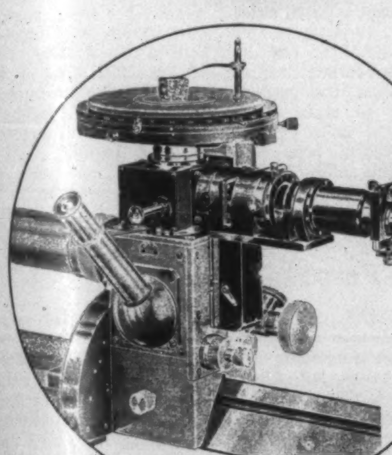
Gold-calcium Alloys (Ueber Gold-Calcium-Legierungen). Fr. Weibke & W. Bartels. *Zeitschrift für anorganische und allgemeine Chemie,* Vol. 218, June 29, 1934, pages 241-248. The stereochemistry of alloys of rare and of base metals was studied by the example of Au-Ca for which the entire constitutional diagram was established. The thermal investigation of this system Au-Ca shows the occurrence of 6 intermediary types of crystal, of which 3 are characterized by maxima (Au_4Ca, Au_2Ca and $AuCa_{1,11}$) while the other 3 are originated by peritectic transformations (Au_3Ca, $AuCa_{1,33}$ and $AuCa_2$). Phase $AuCa_{1,11}$ alone possesses an extensive range of homogeneity, 49-56 atomic % Ca, Au_2Ca and $AuCa_{1,11}$ each form 2 modifications. Microscopic examination (up to 35% Ca) agrees with thermal analysis. Addition of Ca increases the hardness of Au very little but decreases ductility greatly, and the alloys become brittle; Au_4Ca is hard and brittle while Au_3Ca is comparatively soft and can be hammered into thin plates. Alloys from 25 to 70 atomic % are brittle; alloys with higher percentages of Ca approach the properties of pure Ca. Color of the alloys becomes lighter with increasing Ca content. Stability in air is good up to 35% Ca; beyond this, pieces disintegrate quickly into powder. 15 references. Ha (10)

Measuring the Diffusion Velocities of Gases in Solid Phases (Methodik der Messung von Diffusionsgeschwindigkeiten bei Lösungsvorgängen von Gasen in festen Phasen). H. Dünwald & C. Wagner. *Zeitschrift für physikalische Chemie,* Abt. B, Vol. 24, Jan. 1934, pages 53-58. Referring to their previous research on gases in Pd, α-Fe and Cu_2O (See also *Metals & Alloys,* Vol. 4, June 1933, page MA 194-R10) the various factors exerting an influence on the diffusion speed gases in solid phases are pointed out and the formulae for calculating these velocities are presented. EF (10)

Kinetics and Constitutional Diagram for the Irreversible Transformation in the System Iron-nickel (Kinetik und Zustandschaubild der irreversiblen Umwandlung im System Eisen-Nickel). U. Dehlinger. *Zeitschrift für Metallkunde,* Vol. 26, May 1934, pages 112-116. An alloy of Fe and Ni with 29% Ni, frozen into a single crystal, was subjected to analysis for constitution after various heat treatments by means of X-ray rotation photograms. First traces of the α phase were found below 200°. The rate of formation of α from γ at different temperature levels, as judged from the X-ray photograms is plotted, and extrapolated to zero rate which gives a temperature of 200° for the upper conjugate curve of the α+γ region. The lowest temperature at which traces of the γ phase may be detected, —170°, is taken as the temperature for the lower conjugate curve. These temperatures are only approximate since some hysteresis effect may be present here also. The rate curve (plotted as time periods for half conversion) shows a maximum rate at about 80°, a minimum at about 0°; at lower temperatures the rate rises very rapidly. The first maximum corresponds to a precipitation of α accompanied and controlled by diffusion. The rapid increase at low temperatures is characteristic of a transformation proceeding by an atomic shearing process alone, unaccompanied by diffusion, and is therefore similar to the martensite transformation. RFM (10)

Theory of Thermomagnetic and Thermoelastic Phenomena (Zur Theorie der thermomagnetischen und thermoelastischen Erscheinungen). P. Chramov & L. Lwowa. *Zeitschrift für Physik,* Vol. 89, June 16, 1934, pages 443-446. Measurements of the dependence of the e.m.f. of Ni-Cu and Fe-Cu thermocouples on magnetization and tensile stress permitted the conclusion that thermomagnetic and thermoelectric effects are caused by anisotropy of the crystals; the law of Akulov holds good also for thermomagnetic effects. Ha (10)





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Theory of Transformation of Metallic Mixed Phases (Zur Theorie der Umwandlungen von metallischen Mischphasen). G. Borelius. *Annalen der Physik,* Series 5, Vol. 20, May 1934, pages 57-74. The transformations which occur in alloys with a change of temperature and in which both the initial condition as also the final state represent homogeneous solid solutions, are discussed; an example for such transformation is that of Au-Cu alloys at about 400° C. in the concentrations Cu_3Au and CuAu. The mechanics of these transformations is explained in accordance with the results of recent X-ray investigations as a rearrangement of the atoms on the latttice points of the otherwise unchanged lattice. The equations for the calculation of the energy involved in the transformation, conditions of equilibrium and entropy differences are developed and kinds of transformation determined on the basis of electric resistance-temperature curves. One and 2-phase transformations can take place: transformations in one phase and without hysteresis which end at a certain temperature, and transformations in one phase with hysteresis or in 2 phases without hysteresis depending on whether the alloys remain in the metastable equilibrium or go over from the metastable into the stable equilibrium. Experiments have so far given evidence of one-phase transformations; the latter kind has been found with certainty only in an AuCu alloy. The effect of internal stresses on the transformations is discussed. 37 references. Ha (10)

New Information on Mesothorium (Neues vom Mesothorium). A. Bergmann. *Die Metallbörse,* Vol. 24, Feb. 21, 1934, pages 225-226. Due to its radiation of hard gamma rays, mesothorium can be advantageously used instead of X-rays for inspection of metallic parts. The penetration power of the gamma rays is reduced by 1/2, 1/4, and 1/8 by Pb sheets of respectively 10, 20, and 30 mm. thickness. In therapeutics mesothorium proved to be equivalent to radium, whereas the price is 230,000 R.M./g. for the latter and 140,000 R.M./g. for the former. The preparation from monazite sand yields valuable by-products and thus cuts down the manufacturing costs. The production procedure, which yields a few mg. of mesothorium in 9 months, is fully described. EF (10)

Supraconductivity and Its Theoretical Significance (Die Supraleitfähigkeit und ihre theoretische Bedeutung). Carl Benedicks. *Arkiv för Matematik, Astronomi och Fysik,* Vol. 23 A, Oct. 10, 1933, 29 pages (In German.) The supraconducting metals Hg, Sn, Pb, Tl, In, Ga (Leyden) Ta, Ti, Th, Nb (Charlottenburg) are grouped around the fourth column in the periodic table. The break points in binary systems (In-Pb, Hg-Pb, Bi-Pb, Sn-Th, In-Th, Pb-Tl) are in agreement with thermodynamic derivations without calling for the assumption of solubility anomalies around the absolute zero point. Supraconductivity is highly sensitive to heterogeneity of solid solutions. The experimental establishments are interpreted on the basis of the phoretic conductivity theory. Wever (1875) distinguished between 2 factors playing a role during metallic conductivity (1) transition of electricity from atom to atom (2) participation of electricity in the Ampère molecular currents of the atom. This is essentially involved in the fundamental aspects set forth by Benedicks (1915) and designated as phoretic. Supra-conductivity phenomena in metals and alloys are considered as a proof for the reality of the molecular currents (Ampère, Rutherford, Bohr.) EF (10)

Transcrystalline Structure in Tin Bronze. A. Belova. *Tzvetnuie Metallui,* No. 4, May 1933, pages 94-101. The author investigated the influence of temperature factors on the structure and mechanical properties of bronze. Higher casting temperatures were found to produce larger crystals and to favor the columnar crystallization. Increasing the temperature of mold at constant casting temperature produces large grain but hinders the columnar crystallization. Overheating the molten metal promotes columnar crystallization even if the casting temp. is sufficiently low. Optimum structures and mechanical properties can be obtained by selecting proper casting and mold temperatures, the degree of superheating, and the time of cooling to and holding at the casting temperature. BND (10)

Effect of Compressive Stress on Disintegration of Cementite (Der Einfluss einer Druckbelastung auf den Zerfall des Zementits). A. Bruechanow. *Zeitschrift für anorganische und allgemeine Chemie,* Vol. 218, June 5, 1934, pages 146-150. Experiments made with cast bars consisting of pearlite and cementite showed that the stability of Fe_3C (cementite) persists up to temperatures of about 500° C., but under pressure it begins to disintegrate at that temperature and the more the higher the pressure. As the stability of cementite decreases with increasing temperature the effect of pressure becomes less appreciable at higher temperatures and can not be observed above 750° C. Ha (10)

Lattice Constants of α-Fe_2O_3 (Die Gitterkonstanten von α-Fe_2O_3). Rudolf Brill. *Zeitschrift für Kristallographie,* Vol. 88, May 1934, pages 177-178. Redetermination of the α-Fe_2O_3 lattice constants yielded $a = 5.4144$ A.U. $\alpha = 55° \ 14.7'$ which values are in satisfactory agreement with the determination of Katzoff & Ott (*Zeitschrift für Kristallographie,* Vol. 86, Sept. 1933, pages 311-312.) EF (10)

Estimation of the Thickness of the Contamination on the Surface of Metallic Lead. Shinichi Shimadzu. *Memoirs of the College of Science, Kyoto Imperial University,* Series A, Vol. 17, Mar. 1934, pages 79-84. (In Japanese). Powder photographs were obtained by sending K radiations of iron to the surface of lead contaminated by oxide, and it was found that the contamination was composed mostly of microcrystals of tetragonal lead oxide. By comparing the intensity of the diffraction lines due to the contamination and that of the lines of the underlying lead the thickness of the oxide layer was estimated to lie between 50 Mμ and 200 Mμ. HN (10)

The Influence of Grain-size on Magnetic Properties. W. E. Ruder. *American Society for Metals Preprint* No. 11, 1934, 13 pages. Hysteresis loss depends less upon grain size than upon a number of other factors such as purity, thermal and mechanical treatment, and shape of sample tested. Hysteresis bears a close relation to orientation, which is dependent upon the amount and direction of rolling in sheets and strips. 16 references. WLC (10)

X-rays in Industry. *Chemical Trade Journal & Chemical Engineer,* Vol. 94, June 1, 1934, page 414. Resume of a pamphlet issued by the Department of Scientific and Industrial Research (Great Britain) describing the work and facilities of the National Physical Laboratory for the X-ray study of metallurgical and other problems. JN (10)

Reactive Ability of Solid Substances (Ueber das Reaktionsvermögen der festen Stoffe). II. K. Fischbeck. *Zeitschrift für Elektrochemie,* Vol. 40, July 1934, pages 378-394. Treats the ability of solid materials to participate in chemical reactions in presence of gases and liquids. Two groups are distinguished: decomposition of crystals, diffusion in crystals. These processes are exemplified by carburizing, nitriding, and aletizing. The mechanism of these treatments and the importance of equilibria of phases in the diffusion is discussed and the temporal course explained. Influence of temperature and pressure and of impurities on the velocity of diffusion is investigated. The dependence of diffusion on temperature can be fairly well expressed by Langmuir's and Dushman's semi-empirical formula; diffusion increases somewhat up to a certain pressure. Curves and tables show these relations. 151 references. Ha (10)

X-Ray Determination of the $FeAl_3$ Structure (Röntgenometrische Bestimmung der $FeAl_3$ Struktur. Vorläufige Mitteilung). E. Bachmetew. *Zeitschrift für Kristallographie,* Vol. 88, May 1934, pages 179-181. Single crystals of $FeAl_3$ which formed in pipes of a solidifying Fe-Al alloy of 40% Fe max. were investigated by the Laue method. There are 24 molecules in the elementary cell. A Debye test yielded 45 interference lines which partly coincide with the findings of Fink & van Horn. (*Transactions American Institute of Mining & Metallurgical Engineers,* Vol. 93, 1931, pages 383-395.) EF (10)

The Influence of Third Metals upon the Constitution of the Brass Alloys. VI. The Influence of Iron (Der Einfluss von dritten Metallen auf die Konstitution der Messinglegierungen. VI Der Einfluss von Eisen). O. Bauer & M. Hansen. *Zeitschrift für Metallkunde*, Vol. 26, June 1934, pages 122-128. The constitution of brass containing 52-100% Cu, 0-2% Fe in addition to Zn, was investigated by thermal and microscopic methods. Additions to 70% Cu brass of up to 1% Fe increase the liquidus temperature very slightly, if at all, and depress the α + liquid = β peritectic temperature a few degrees. Fe in excess of 1% brings about a marked rise in the liquidus temperature. The solid solubility of Fe in α and β brass is similar in extent to that in Cu. By additions of Fe the boundary of the ($\alpha + \beta$) field is displaced toward lower Cu concentrations, the Fe replacing about an equal percentage of Cu. Grain growth on recrystallization of α brass is retarded by the presence of Fe and additions of Fe in excess of 1% cause grain refinement in cast α brass. Ternary Cu-Zn-Fe alloys are susceptible to precipitation hardening. 19 micrographs, 16 diagrams, 51 references. FNR (10)

Internal Stresses. Part II. Correlated Abstract. Charles S. Barrett. *Metals & Alloys*, Vol. 4, July 1934, pages 154-158. Reviews the use of Laue technique in study of internal stresses which indicate that it is unreliable for either quantitative or qualitative measurements in this field but that its greatest usefulness is in the study of orientation changes during plastic deformation. 24 references. WLC (10)

Mechanism of Plastic Deformation of Iron Monocrystals (Ueber den Mechanismus der plastischen Deformation der Eiseneinkristalle). N. Akulov & S. Raewsky. *Annalen der Physik*, Series 5, Vol. 20, June 1934, pages 113-117. An Fe monocrystal was subjected to compression beyond elastic limit in the [100] direction and the suspension figures forming in the plane (010) were examined. An effect of the periodic change of direction on the lines of Bitter (S-lines) could be stated which indicates periodically alternating sliding along the planes (100), (010) and (001) under uninterruptedly increasing deformation. The phenomenon is illustrated by photographs of etched specimens. Ha (10)

A Note on Chromium Oxide Inclusions in Stainless Steel and Ferro-chromium. M. Baeyertz. *Transactions American Society for Metals*, Vol. 22, July 1934, pages 625-634. Duplex inclusions of chromium oxide and methods of analysis of their structure by use of both transmitted and reflected light and an acid permanganate etch are described. WLC (10)

On the Formation of Layer-lattices. H. Arnfelt. *Arkiv für Matematik, Astronomi och Fysik,* Vol. 23 A, Oct. 10, 1933, 6 pages. In English. X-ray studies on the process of graphitization (graphite, petrol coke, SiC). Photograms from certain samples of graphite show interferences of abnormal intensities. Graphite precipitated from a melt of Fe saturated with C shows very good X-ray lines. In this case the dissolved C atoms have a good opportunity to arrange themselves when they are deposited from the melt. On the other hand, graphite produced by the disintegration of cementite gives photograms similar to those of Acheson graphite. This is due to the smaller mobility of the C atoms when deposited from the solid. The low rate of graphitization of some carbons is pointed out. The solubility and vapor tension of the more amorphous state must be greater than those of the more crystallized one. EF (10)

Parameter Values of Copper-nickel Alloys. E. A. Owen & Llewelyn Pickup. *Zeitschrift für Kristallographie,* Vol. 88, May 1934, pages 116-121. (In English). Measurements accomplished with an X-ray camera of ± 0.000 A. U. precision on the parameters of the Cu-Ni alloys shows that there is a contraction when the alloys are formed from the 2 pure metals. The maximum contraction, which amounts to 0.11%, occurs at about 34 at. % Ni. This contraction is smaller than that recorded by previous investigators (Lange & Holgersson, Burgers & Basart). From the parameter values, the densities of the alloys were calculated, the maximum density at 18°C. being 8.949 g./cm.^{3} for the alloys containing 34 at. % Ni. The densities of pure Cu (99.98% and pure Ni (99.98%) were 8.938 and 8.895 g./cm.^{3} respectively. EF (10)

Influence of the Method Used on the Value for the Heat Content of Iron (Einfluss des Untersuchungsverfahrens auf den gemessenen Wärmeinhalt des Eisens). H. Esser & W. Bungardt. *Archiv für das Eisenhüttenwesen,* Vol. 8, July 1934, pages 37-38. A critical survey of the existing data, particularly on the heat effects at A_2 and A_3; the heat effect at A_3 is evaluated to be 3.6 cal/g. SE (10)

A Constitutional Diagram for Ternary Alloys (Ein Zustandschaubild für Dreistofflegierungen). V. Fischer. *Zeitschrift für Metallkunde,* Vol. 26, Apr. 1934, pages 80-82. Sections of a ternary system may be represented on a single plane diagram. At a given percentage of one component in two of the binary systems the solidus and liquidus temperatures are read off; one of these pairs of temperatures is transferred to one of the ordinates and the liquidus and solidus curves for the section introduced and represented by lines drawn to the other pair of temperatures. The original article must be consulted for a full explanation. The systems Ni-Cu-Mn, Ag-Au-Cu, and Ag-Pb-Sn are represented in this way. RFM (10)

The Rate of Cementite Decomposition in Cast Iron (Der zeitliche Verlauf des Zementitzerfalls im Gusseisen). E. H. Klein. *Stahl und Eisen,* Vol. 54, Aug. 9, 1934, pages 827-830. Cast iron samples with coarse and fine graphite flakes were heated in N_2 at 500 to 700°C and the length changes measured with a dilatometer. The increases in length corresponded with the decomposition of cementite to graphite, the rate of decomposition and its increase with temperature being indicative of a first order reaction. The cementite decomposed more rapidly in the samples with fine than in samples with coarse graphite. SE (10)

The X-Ray Study of Red Monoclinic Selenium. Proof of the Existence of Two Red Monoclinic Varieties of Selenium. Harold P. Klug. *Zeitschrift für Kristallographie,* Vol. 88, May 1934, pages 128-135. (In English.) Crystals of Muthmann's α and β modifications of red monoclinic Se have been investigated by means of Laue and oscillation photographs and the separate identity of the β variety proved. In agreement with the work of Halla, Bosch & Mehl the unit cell of the α form was found to contain 32 atoms of Se and to have the dimensions:

$a_o' = 8.992$ A. U. $b_o' = 8.973$ A. U. $c_o' = 11.52$ A. U. $\beta' = 91° 34'$

The space group of the α form is probably C^2_{2h}. The β variety has a cell with the following dimensions:

$a_o = 12.74$ A. U. $b_o = 8.04$ A. U. $c_o = 9.25$ A. U. $\beta = 93° 4'$

It is probable that the cell contains 32 atoms, in which case the calculated density of the β form is 4.42. Its space group is probably C^5_{2h}. The possibility of a structure closely similar to that of rhombic S is pointed out, especially for the α form. EF (10)

Relation Between Lattice Parameter and Ferromagnetism (Zusammenhang zwischen Gitterparameter und Ferromagnetismus). W. Köster & W. Schmidt. *Archiv für das Eisenhüttenwesen,* Vol. 8, July 1934, pages 25-27. Lattice parameter measurements at elevated temperatures indicated that paramagnetic β-Fe expands at a greater rate with temperature than ferromagnetic α-Fe. A similar effect was observed in the systems Co-Mn, Fe-Co-Mn, and Ni-Mo, the lattice parameters of the paramagnetic γ solid solutions increasing at a greater rate with temperature than the ferromagnetic solid solutions. It was concluded that body centered cubic Fe on changing from the ferromagnetic to the paramagnetic form contracts 1.6% in atomic volume, and similarly face centered cubic Ni and Co contract 1.0 and 2.3% respectively. SE (10)

The Inner Mechanics of Metals (Über innere Mechanik der Metalle). W. Kuntze. *Zeitschrift für Metallkunde,* Vol. 26, May 1934, pages 106-112. A general discussion and review, in which analogies are drawn between the behavior of wood on deformation and that of metals. RFM (10)

PROPERTIES OF METALS & ALLOYS (11)

Practical Method for Determining Thermal Conductivity of Small Metal Bars (Méthode Pratique pour la Détermination de la Conductibilité thermique de Petits Barreaux Métalliques.) P. Vernotte. *Science et Industrie,* Vol. 17, Apr. 1933, pages 183-185. In present section of the article construction of apparatus is explained in detail in order to be available to any industrial laboratory. FR (11)

The Recovery of Metals and Alloys from the Effects of Cold Work (Die Erholung metallischer Werkstoffe von den Folgen der Kaltbearbeitung). G. Tammann. *Zeitschrift für Metallkunde,* Vol. 26, May 1934, pages 97-105. A review. RFM (11)

Supraconductivity in Alloys (Die Supraleitung von Legierungen) G. Tammann. *Zeitschrift für Metallkunde,* Vol. 26, Mar. 1934, page 61. A very brief review. RFM (11)

Laws of Elastic Behavior. M. F. Sayre. *Transactions American Society of Mechanical Engineers,* Vol. 56, July 1934, pages 555-558. Paper presented at annual meeting of American Society of Mechanical Engineers, Dec. 4-9, 1933. To aid in problems of design where resilience or deflection is involved, elastic behavior which deviates widely from the simple explanation given by Hooke's law is discussed. Where loads are high enough to require accurate knowledge either of stresses or of deflections, these deviations cannot be ignored. Statements (some necessarily more or less theoretical) emphasize particularly factors brought out in work at Union College for last few years under auspices of A. S. M. E. Special Research Committee on Mechanical Springs: hydrostatic pressures, shearing stresses, direct tensile or compressive stresses, and bending stresses. MFB (11)

Titanium Alloys in the Automotive Industries. Geo. F. Comstock. *Machinery,* N. Y. Vol. 40, June 1934, page 609. To assure the high ductility required for auto-body sheets a steel of less than 0.06% C. is used; this steel must be deoxidized with a ferro-carbon-titanium of especially low C content. Ti improves also the smoothness of the surface so that a better surface finish is obtained. Ti is further used to make hard, strong alloy compositions more easily machineable and to close the grain or decrease the size of graphite flakes. A Ti-alloy, "Webbite," has recently been developed for improving Al alloys; addition of about 2½ lbs. of this alloy to 100 lbs. of Al containing 8% Cu reduces grain size and improves strength, soundness and resistance to leakage of castings to a marked degree. Ha (11)

Non-Ferrous (11a)

A. J. PHILLIPS, SECTION EDITOR

Influence of Heavy Metals upon Aluminum Alloys. Part 2. The Influence of Chromium (Einfluss von Schwermetallen auf Aluminiumlegierungen. 2. Mitteilung: Ueber den Einfluss von Chrom). P. Röntgen & W. Koch. *Zeitschrift für Metallkunde*, Vol. 26, Jan. 1934, pages 9-18. The effect of additions of Cr on the constitution, structure, tensile strength, elongation, hardness, and age-hardening capacity of alloys of Al-Cu, Al-Ni, Al-Mn, and Al-Cu-Ni, and of the alloy Lautal are reported. The composition ranges are as follows: Al-Cu-Cr, 0.1 to 2.5% Cr, 1 to 10% Cu; Al-Ni-Cr, 0.1 to 4% Cr, 1 to 10% Cu; Al-Mn-Cr, 0.1 to 2% Cr, 1 to 8% Mn; Al-Cu-Ni-Cr, 0.5 to 3% Cr, 1 to 6% Cu, 0.5 to 5% Ni; Lautal, 0.1 to 2.5% Cr, 4% Cu, 2% Si. The data on mechanical properties are given in a table, and the structures are illustrated in 19 photomicrographs. The alloys studied all showed good mechanical properties. Alloys of Al-Ni-Cr and Al-Mn-Cr do not age-harden. Alloys of Al-Cu-Cr do age-harden because of the Cu present. The known injurious effect of Ni on the hardening of Al-Cu alloys was observed in alloys of Al-Cu-Ni-Cr. The mechanical properties of Lautal are improved by the addition of Cr; the optimum ratio of Cr to Cu is between 1:10 and 1:5. **Part 3. The Influence of Molybdenum (3. Mitteilung: Über den Einfluss von Molybdän)** ibid, pages 13-18. Tests similar to those in Part 2 were performed on Al-Cu alloys with the addition of Mo between 0.1 and 2% and also on these alloys with the addition of Ni, Cr, Co, Fe, Mn, Si, Mg, Zn, and Al (in proportions impossible to describe briefly) using chiefly the base alloy 4% Cu and 1% Mo. Tensile strength data up to 400° are given. The replacement of Cu in these alloys by Si, or Mg and Si, is of little use. The alloys containing Cu and Mg age-harden and thus develop useful mechanical properties. See also *Metals & Alloys,* Vol. 5, May 1934, page MA 213. RFM (11a)

Recent Developments in Lead for Chemical Plant. W. Singleton. *Journal Society Chemical Industry,* Vol. 53, Feb. 23, 1934, pages 49-52T. Additional information on tellurium lead (lead containing less than 0.1% Te) is given (See Singleton & Jones, *Journal Institute of Metals,* Vol. 51, 1933, page 71). Tellurium lead has markedly increased resistance to corrosion in many conditions. The toughness of tellurium lead sheet can be controlled, so that it can be produced in the soft or toughened condition. Its increased strength as compared with ordinary lead is greater in proportion at 100° C. than at ordinary temperatures. After overstraining 12.5% in tension, tellurium lead continues to increase in strength until 21% greater strength is reached after 6 months—the duration of the test. In similar conditions lead shows 12% loss in strength. Grain growth which takes place in lead is practically absent in tellurium lead. The effect of grain growth is discussed, and it is shown that strain readily produces grain growth in lead. The effect of uniformity and fineness of grain is discussed, showing that coarse and unequal grains produce uneven distribution of strain leading to intercrystalline cracking. The refined and uniform grain and the uniform distribution of strain in tellurium lead are illustrated. Tellurium lead is three times as resistant to vibration as ordinary lead. VVK (11a)

The Influence of Pickling on the Fatigue-Strength of Duralumin. H. Sutton & W. J. Taylor. *Journal Institute of Metals,* Vol. 55, Advance Copy No. 668, June 1934, 11 pages. Wöhler-type specimens were pickled by several methods and the influence of pickling on the fatigue strength determined. In no case did the pickling remove enough metal to affect the indicated strength by decrease in diameter. Pickling in NaOH followed by HNO_3 plus H_2SO_4 lowered fatigue strength by as much as 31%. When a thin surface layer was machined away after pickling the material showed a normal fatigue strength. Pickling in HF plus HNO_3 lowered fatigue strength by 15%. Pickling 3 min. in 4 parts 10% H_2SO_4 and 1 part HF followed by 1 min. in 50% HNO_3 lowered fatigue strength by 6%, and when this was followed by dipping in boiling water the strength returned to normal. The last pickling method is entirely satisfactory for showing defects. JLG (11a)

The Improvement of White Bearing Metals for Severe Service: Some General Considerations. D. J. Macnaughtan. *Journal Institute of Metals,* Vol. 55, Advance Copy No. 673, July 1934, 15 pages. Stresses in bearings, particularly those leading to failure, are discussed. Mechanism of crack formation is described and it is suggested that a high fatigue limit is advantageous in preventing cracking. Tensile strength, Brinell hardness, and fatigue range of Sn-rich alloys containing 3.5% Cu and as much as 12% Sb are given. As Sb content increases all 3 properties increase. The addition of 1% Cd to the above alloys increases hardness, strength, and by inference fatigue range. Resistance to pounding and ductility may be important properties of bearing materials. 13 references. JLG (11a)

Arsenical and Argentiferous Copper. J. L. GREGG. American Chemical Society Monograph Series No. 67. Chemical Catalog Company, New York, 1934. Cloth, 6 x 9¼ inches, 189 pages. Price $4.00.

A compendium of information on the properties and uses of arsenical and argentiferous Cu, together with similar data on Cu itself for comparative purposes. The effect of O, As, and Ag on electrical conductivity, the effect of As on thermal conductivity, the effect of As and Ag on the annealing temperatures and mechanical properties of Cu and the corrosion of arsenical Cu and brass are discussed. On the basis of these properties the author describes uses for which arsenical and argentiferous coppers are especially well adapted.

A. H. Emery. (11a) -B-

Experiments in Wire-drawing. Part IV.—Annealing of H.-C. Coppef Wires at Varying Hardness-Elongation Values. W. E. ALKINS & W. CARTWRIGHT. *Journal Institute of Metals,* Vol. 55, Advance Copy No. 670, June 1934, 9 pages. Elongation values of wires whose tensile properties were given in an earlier paper are given. Wires were drawn from a tough-pitch Cu of high purity. The influence of amount of cold work, annealing temperature and annealing time on elongation are indicated. JLG (11a)

Influence of a Small Addition of the Elements upon the Properties of Al Alloys. HIDEO NISHIMURA. *Suiyokwai-shi,* Vol. 8, Mar. 5, 1934, pages [illegible]-390. (In Japanese). Molten Al and Al alloys containing 4-5% Cu were treated with various chloride fluxes, such as $MnCl_2$, $NiCl_2$, $CoCl_2$, $CuCl_2$, and the quantities of Ni, Mn, Co and Cu alloyed with Al were determined. Mn was the most easily dissolved in Al or Al alloys. The temperature of treatment did not influence the quantity absorbed. The effect of a small amount of Ti. (0.02-0.[illegible]), on the aging of Al alloys containing 4-5% Cu was investigated by measuring the change in electric resistivity and hardness with temperature. The microstructure of heat treated alloys was also examined. Ti did not tend to decrease the hardness of the alloys at higher temperatures. HN (11a)

Sodium Metal. *Chemical Trade Journal & Chemical Engineer,* Vol. 93, Aug. 11, 1933, pages 99-100. Abstract of an article on the handling and use of Na in plant and laboratory by Gilbert, Scott, Zimmerli, and Hansey, *Industrial & Engineering Chemistry,* July, 1933. See *Metals & Alloys,* Vol. 5, Mar. 1934, page MA 77. JN (11a)

Platinum-Chromium Alloys. V. A. NEMILOV. *Transactions of Platinum Institute,* No. 11, 1933, pages 125-134 (In Russian); *Zeitschrift für anorganische und allgemeine Chemie,* Vol. 218, May 18, 1934, pages 33-44. Alloys were made of Kahlbaum Cr and Pt sponge containing about 0.01% impurities. Heats of 15-20 g. were melted in an induction furnace, tested for Brinell hardness, microstructure, electrical and thermal conductivity. Alloys were annealed for 5 days at 1100°C and their Brinell hardness determined. It did not vary from the hardness obtained after annealing for 1-2 hours at 14[illegible]0°C. Pt addition to Cr increases hardness to 300 with 25% Pt, rapidly drops to a minimum with 34% Pt, brings it to 280 with 45% Pt, lowers it to a second minimum with 50% Pt sending it to another maximum of 280 with about 60 at. % Pt, after which the hardness decreases gradually to that of pure Pt. Minima correspond, apparently, to intermetallic compounds $PtCr_2$ and PtCr. Quenching from 1100°C. and 1450°C. does not change hardness. Quenching from under the melting point makes the alloys too brittle for hardness measurement. In quenched state all alloys form solid solutions. In annealed state alloys up to 25 at. % Pt form solid solutions, $PtCr_2$ is formed at 33.3 at. % Pt, PtCr is formed at 50 at. % Pt and a higher Pt content than 65% results in a series of solid solutions. Alloys with about 34% Pt form acicular crystals after annealing which are changed into a granular solid solution by quenching from above 1450°C. Annealing develops in 45-67 at. % Pt alloys a combination of acicular and twin structure transformed into a typical solid solution by quenching. Cr makes Pt brittle so that wires cannot be made from alloys containing more than 3.86 weight % Cr. At this composition the specific resistance at [illegible]°C and 100°C was 63.38 and 64.65 as compared with 10.882 and 13.797 for pure Pt. With Cr less than 14 at. % H_2SO_4 and HNO_3 have no effect and heating in air at 1100°C. for 5 days is likewise without effect. Ha (11a)

Crystal Densities of Industrial Brasses from X-ray Data. E. A. OWEN & LLEWELYN PICKUP. *Journal Institute of Metals,* Vol. 55, Advance Copy No. 672, June 1934, 8 pages. The available data on lattice parameters of Cu-Zn alloys are summarized. Methods for calculating densities from these data are described. Porosity of brasses can be calculated most accurately by comparing calculated values of density with observed values. Alloys, however, must be in true equilibrium if reliable results are to be obtained. 4 references. JLG (11a)

Some Properties of Heavily Cold-Worked Nickel. H. QUINNEY. *Journal Institute of Metals,* Vol. 55, Advance Copy No. 667, May 1934, 12 pages. Samples of Ni were cold worked by torsional stresses and the Curie point determined. Cold working raised the point found on heating, but the point returned to its normal position on cooling. With Ni of 99.62% purity the Curie point was at 330°C. With Fe, cold working did not affect the temperature of the Curie point because the effects of working were removed before the point was reached.

JLG (11a)

The Alkaline-Earth Metals. CHARLES HARDY & PAUL M. TYLER. *Chemical Trade Journal & Chemical Engineer,* Vol. 92, Apr. 14, 1933, pages 299-300. A discussion of metallic Ca, Sr and Ba; their physical properties, uses, alloys, metallurgical applications, availability, and costs. JN (11a)

The System Germanium-Tellurium (Das System Germanium-Tellur) W. KLEMM & G. FRISCHMUTH. *Zeitschrift für anorganische und allgemeine Chemie,* Vol. 218, June 29, 1934, pages 249-251. The diagram of state of the system Ge-Te was established. it is very similar to that of Sn-Te and Pb-Te. Only one chemical compound exists. GeTe which melts incongruently at 725±3°C. All mixtures could be obtained by synthesis in an evacuated quartz tube. GeTe has a metallic appearance, a density (at 25°C.) of 6.20±0.02; it is little attacked, even heated, by concentrated HCl and H_2SO_4 and by H_2O_2. Strong HNO_3 attacks a little also cold, somewhat more when heated. It is dissolved completely by cold aq. regia and H_2O_2-HCl mixture. 4 references. Ha (11a)

The Behaviour of White Bearing Metals When Subjected to Various Deformation Tests. Part I—Indentation Tests. A. S. KENNEFORD & HUGH O'NEILL. **Appendix on An X-ray Examination of Babbitt Metal and of the Age-Hardening of Cast Lead-Alkali Alloys.** G. S. FARNHAM. **Part II—Tensile Tests.** R. ARROWSMITH. **Part III—Pounding Tests.** H. GREENWOOD. *Journal Institute of Metals,* Vol. 55, Advance Copies Nos. 674, 675, & 676, July 1934, 39 pages. Tests were made on high-Sn alloys of the Babbitt type, an alloy containing almost equal parts of Sn and Pb, high-Pb bearing alloys, and alkali-Pb bearing alloy, pure Sn and pure Pb. Small amounts of Cd, Mg, Ni, and Pb had been added to some of the Babbitts. Several types of indentation tests, with ball and with cone, were made on each alloy. Tests were made at room and elevated temperatures. The Herbert pendulum appeared to give valuable data. The addition of 1% Cd to Babbitt increased the hardness at 150°C. The structure of SnSb in Babbitt was determined by X-rays and found to be of the NaCl type with a = 4.099 A. U. The CuSn phase in Babbitt (the needles) corresponded to CuSn (63% Sn). Two phases were found in the Pb-alkali bearing metal. Tensile tests, including stress-strain curves, showed the influence of composition and casting conditions on tensile properties. Pounding tests with cylindrical samples did not yield the desired information. Tests were then made with bearing-shaped specimens with a cylindrical indenter at temperatures of 18, 100, and 150°C. Babbitt with Cd gave the greatest resistance to pounding. 25 references.

JLG (11a)

The Bronzes (Les Bronzes). GODFROID. *Revue de Fonderie Moderne,* Vol. 28, May 25, 1934, pages 141-145; June 10, 1934, pages 163-166. The advantages of using, in many cases, Cu alloys, in particular bronzes, instead of steel because of rusting, high melting point, difficulties of molding of the latter, are pointed out. Properties and numerous industrial applications of bronzes are described; the behavior of bronzes under friction as bearing metal as dependent on lubrication and nature of metals in contact is discussed; the friction coefficient is, for the same bronze and the same lubricant, the lower the more homogeneous the structure of the metal bearing on the bronze. The nature of the bronze applied as bearing metal can, therefore, change very much according to the nature of the second metal. Equilibrium diagrams and properties of ordinary and Al bronzes are given. Ha (11a)

The Free Energy of Formation of Lead Amalgams. CREIG S. HOYT & GEBHARD STEGEMAN. *Journal of Physical Chemistry,* Vol. 38, June 1934, pages 753-759. Concentration cells having pure Pb as one pole and Pb amalgams of varying concentration as the other have been constructed and their potentials measured. Reproducible potentials are secured with amalgams up to 66 at.% Pb. The amalgam is saturated at 0.0142 mole fraction at 25.00°C. and all amalgams between that concentration and 0.66 give the same potential. The free energy of formation of amalgams up to a mole fraction of approximately 0.50 have been calculated as well as the activities of Pb and Hg in the amalgams. The heat of solution of Pb in unsaturated amalgams has been calculated from the temperature coefficient of the e.m.f. EF (11a)

The Properties of Aluminum and Two of its Alloys at Elevated Temperatures. F. M. HOWELL & D. A. PAUL. *Metals & Alloys,* Vol. 5, Aug. 1934, pages 176-179. Reports the effects of prolonged heating of pure Al, 1.25% Mn-Al alloy, and 1.25% Mn, 1.0% Mg-Al alloy on the stability of physical properties as shown by elevated temperature tests of both the short and creep type and room temperature tests. Results indicate that prolonged exposure to 200°-300°F. is without effect, ½ hard Mn-Al alloy shows no noticeable loss of hardness by heating to 300°F. and other alloys only slight loss. Heating at 212° and 300°F. of pure Al and Mn-Al alloy in strain hardened condition results in 20% increase in yield point with no change in tensile strength. Full hard tempers of all alloys lose their hardness more rapidly than ½ hard and at temperatures about 100°F. lower. WLC (11a)

Special Alloys (Spezial-Legierungen) *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, Apr. 15, 1934, page 164; Apr. 29, 1934, page 191. The composition, properties, and applications of the following alloys are discussed: (1) Emperor bearing metal, (2) Erhard bronze, containing Zn, Cu, Al, (3) Haberland composition, practically a pure Sn bronze with 10% Sn, distinguished by corrosion stability. (4) Haberland metal, a pure binary brass with but 13% Zn, (5) Halumin, a Japanese Al alloy containing 2.3% Mn, 2% Ni, 1.5% Cu, .5% Fe and .1% Si, (6) Hamilton gold, (7) Hammonia bearing metal containing 64.5% Sn, 32.3% Zn and 3.2% Cu. GN (11a)

Lithium Production and Uses. *Chemical Trade Journal & Chemical Engineer,* Vol. 91, Sept. 30, 1932, pages 297-299. Abstract of 27-page monograph isued by Mineral Resources Department of Imperial Institute, London. See *Metals & Alloys,* Vol. 4, Sept. 1933, page MA 275. JN (11a)

New Types of Silumin (Nya typer av silumin) ERIK HALLSTRÖM. *Teknisk Tidskrift,* Vol. 64, June 16, 1934, pages 252-254. Gives analyses and physical characteristics of a series of new silumin alloys recently brought out in Germany, such as copper-silumin with 0.8% Cu and 0.3% Mn; Silumin-beta with 0.3% Mg and 0.45% Mn, and silumin-gamma, which has the same chemical composition as beta but has undergone a hardening process, for 20 hr. at 150°, or for 3 hr. at 510° C., followed by 20 hr. at 150° C. The small content of manganese used in these alloys increases tensile properties without affecting adversely the corrosion resistance. Casting in sand, metal molds, and die casting of the alloys are discussed, also their use in airplane construction. Cobalt and chromium may have the same effect as manganese. Silumin-gamma when subjected to long hardening treatment may show tensile properties and hardness twice as high as copper-silumin, and also greater corrosion resistance. These alloys also show great fatigue resistance. BHS (11a)

New Bearing Materials (Neue Werkstoffe für Lager) *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, Apr. 8, 1934, page 213. Discusses the following new bearing metals: (1) a series of bearing alloys containing Cu, Zn, Si as processed by Hirsch, Kupfer-und-Messingwerke, Eberswalde, (2) bearing alloy of Th. Goldschmidt containing Sn, Sb, Cu, Ni. These alloys possess excellent running qualities and are especially fit for heavy loaded bearings of high speed machines, typical composition: 77% Sn, 15% Sb, 1.5% Ni, 3% Cu, 0.1% P, 0.5% Mn, 2% Cd, (3) a series of Pb bearing alloys developed by Ricard, Paris, containing 23-38% Pb, 52-68% Cu, 5-8% Ni, 2-4% Si, 0.5-1.5% Fe, (4) forged bronzes made according to a patent of Heraeus, Hanau, distinguished by best fatigue properties (5) Volvit bronze of Osnabrück, Kupfer-und Drahtwerke, made of purest Cu (91%) and Sn (9%); this bronze in shape of drawn tubes possesses high tensile strength (40 kg/mm.^{2}) and elasticity. GN (11a)

New Developments and Experiences with Beryllium (Neue Entwicklungen und Erfahrungen mit Beryllium, dem leichtesten Metall) *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, June 3, 1934, page 344. Briefly discusses properties of Be bronze, Be-Ni alloys and Be special steels on Cr-Ni base being distinguished in particular by high hardness, high resistivity against corrosion by acids and high hot tensile strength. GN (11a)

Tellurium Lead Resistant to Corrosion. *Engineering & Mining Journal,* Vol. 135, July 1934, page 333. Pb containing less than 0.1% Te is superior to ordinary Pb in its resistance to corrosion by acids, its greater tensile strength, its increased resistance to fatigue failure, and its generally better working qualities. The grain formation is extremely fine and uniform. WHB (11a)

The Resistance of Manganese Arsenide. L. F. BATES. *London, Edinburgh and Dublin Philosophical Magazine and Journal of Science,* Vol. 17, Apr. 1934, pages 783-793. The variation of electric resistance of manganese arsenide with temperature was found to have an intimate connection with the energy of spontaneous magnetization; it is represented by an irregular curve. 9 references.

Ha (11a)

Ferrous (11b)

E. S. DAVENPORT, SECTION EDITOR

Some Observations on High-Speed Steel. E. WIDDOWSON. *Mechanical World & Engineering Record,* Vol. 95, Apr. 13, 1934, pages 358-360. Crucible steels are superior because the "body" enables them to withstand exacting service conditions. Open-hearth furnace steels hardly come within the scope of quality steels. The composition of any "as cast" ingot, particularly of high-speed steel containing up to 38% alloys, varies from surface to center due to selective freezing, with the resultant formation of eutectic areas. Forging achieves destruction of the original coarse structure, with consequent equalisation of chemical composition. Ingot defects and core weakness are discussed. Importance of a slow rate of cooling from, or heating to, forging temperature is stressed. Cold work introduces a permanent state of tension and weakness which no annealing or similar operation will eliminate. Composition of steels discussed: 0.65-0.80% C; 14.0-22.0% W; 3.5-5.0% Cr; 1.0-2.07% V; in special cases 5.0-12.0% Co. Low thermal conductivity demands slow and even heating. Hardening temperature varies between 1275° and 1325° C. Effect of incorrect heat treatment is illustrated by photomicrographs. High-speed steel develops its greatest degree of toughness and ductility when tempered at 500° C. but to produce maximum secondary hardness the tempering temperature should range between 540°-560° C.

Kz (11b)

Sublimed Iron (Ueber das sublimierte Eisen). W. KROLL. *Zeitschrift für Elektrochemie,* Vol. 40, June 1934, pages 303-306. The vapor pressure-temperature curve of metals shows considerable pressure at high temperatures while at lower temperatures very low pressures are observed.

	Temperature °C to develop pressure of 760 mm. Hg	Temperature °C to develop pressure of 0.001 mm. Hg	Melting point °C.
Co	3168	1254	1478
Fe	3235	1267	1533
Mn	1900	861	1264
Ni	3147	1250	1453
Zn	906	296	419.4
Mg	1070	576	650
Ca	1174	731	850

This suggests the possibility of subliming Fe at low temperature by reducing the pressure. An experiment resulted in sublimation of 0.054 g. Fe per cm.^{2} per hr. at 1100°-1200° C. The production of very pure metals by sublimation was indicated to be out of the question due to volatilization of impurities. Ha (11b)

Measure of Stress in Cast Iron (Ueber das Mass der Anstrengung bei Gusseisen). A. LEON. *Mitteilungen des Technischen Versuchsamtes Wien,* yearly Vol. 22, 1933, pages 17-42. Various theories for expressing stresses in materials are discussed with particular reference to linear, plane and spatial stresses in cast Fe. Numerical values obtained in experiments by various methods are evaluated statistically; Mohr's theory is found to be the most satisfactory for connecting tensile and compression fracture. 8 references. Ha (11b)

Quality or "Body" of Carbon Tool Steel, Crucible Melted. FREDERICK C. A. H. LANTSBERRY. *Metal Progress,* Vol. 25, Mar, 1934, pages 20-23. Carbon tool steel still holds an important place as raw material for tools. The use of alloy steel, tool and structural, proceeded only as the treatment problems were solved. True index of quality is dependability; this comes with high grade raw materials, skillful melting and casting, proper analysis, freedom from mechanical inclusions of slag and uniform distribution of finely divided non-metallic matter. Skillful thermal and mechanical treatment in finishing will result in a steel with uniform response to heat treatment. The nature of the crucible process requires that these conditions be adhered to and its merit for production of tool materials is still recognized in Europe. WLC (11b)

Chromador Steel. *Engineering,* Vol. 137, April 6, 1934, pages 415-416. From paper presented by Gilbert Roberts before the Institution of Structural Engineers, London, Mar. 22, 1934, entitled "A New High-Tensile Steel for Structural Work." LFM (11b)

Inverse (or Internal) Chill in Gray Cast Iron. C. HOWELL KAIN. *Foundry Trade Journal,* Vol. 49, Oct. 12, 1933, pages 201-203. Deals with the comparatively rare phenomenon of inverse (or internal) chill. Defines what is meant by internal chill and refers to experiences in the production of this defect. Inverse chill was largely independent of composition; for the same thickness of sec- sand molds; there appeared to be a critical casting temperature at about 1480° C. tion the defect was frequently found to be present in dry sand and absent in green Six main reasons have been advanced to account for this defect: steam (or moisture); superheating; mould condition; pressure; differential cooling. These are discussed together with the reasons why the last is the most acceptable. OWE (11b)

The Value of Young's Modulus for Steel. H. H. ABRAM. *Iron & Coal Trades Review,* Vol. 128, June 29, 1933, pages 1063-1064. See *Metals & Alloys,* Vol. 5, Sept. 1934, page MA 348. Ha (11b)

Cast Iron Suitable for Nitrogen Hardening. J. E. HURST. *Iron & Steel Industry,* Vol. 7, Nov. 1933, pages 47-52. See "Nitricastiron. Cast Iron Suitable for Hardening by the Nitrogen-Hardening Process," *Metals & Alloys,* Vol. 4, Nov. 1933, page MA 354. CEJ (11b)

Properties of Ferrite as Revealed by Scratch Hardness Tests. H. W. GILLETT. *Metals & Alloys,* Vol. 5, July 1934, pages 159-160. Review of scratch hardness testers shows them to be impractical for commercial work. Effects of Si, Mn, C and FeO on the hardness of ferrite are reviewed. WLC (11b)

Effect of Various Alloys in Steel. N. L. DEUBLE. *Heat Treating & Forging,* Vol. 20, July 1934, pages 326-330. Discusses effects of Mn, Ni, Cr, Mo, V, W, Si and Cu. Limited, with several exceptions, to the standard S.A.E. types. MS (11b)

An Investigation of Welded Tubes of Copper Steel. L. SINAISKII. *Stal,* Vol. 4, Feb.-Mar. 1934, pages 61-71. The addition of 0.3% Cu to tubing steel (0.1% C) increases tensile strength 10%, hardness 12%, elongation 22%, resistance to corrosion in H_2SO_4 12 times, and in HNO_3 twice. The steel welds very easily. HWR (11b)

Simple Facts about Common Steel. J. R. MILLER. *Heat Treating & Forging,* Vol. 20, Apr. 1934, pages 178-181; July 1934, pages 348-349, 359. Elementary discussion of manufacturing processes, elements usually present, effect of C content and of working, compositions for definite purposes, and special characteristics of Bessemer as compared to open-hearth steel. Part 2 discusses heating and rolling of steel. MS (11b)

Hydrogen Embrittlement of Steel as a Function of the Amount of Hydrogen Absorbed (Die Wasserstoffbrüchigkeit des Stahls in Abhängigkeit von der aufgenommenen Wasserstoffmenge). P. BARDENHEUER & H. PLOUM. *Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung, Düsseldorf,* Vol. 16, No. 11, 1934, pages 129-136. H can be absorbed by steel during pickling or by cathodic electrolysis and has a harmful influence on mechanical properties, steel or iron becoming brittle after pickling. Bending and torsion tests were made and the deterioration of the material thus determined. The change brought about by H absorption disappears gradually on storage or during rapid heating, but the original condition is not restored. Cold working favors the removal of H. Absorption of H at room temperature decreases with increasing degree of cold-working. Ha (11b)

Copper Improves Steel Properties. H. FOSTER BAIN. *Steel,* Vol. 94, Apr. 16, 1934, page 32. Abstract of address before the Cleveland Chapter of the American Society for Metals, Apr. 9, 1934. Research work at Battelle Memorial Institute indicates that 1.5% Cu in rolled steel improves physical properties 10-20% without heat treatment; heat treatment effects an additional improvement of 10-15%. Tensile strength of cast steel is raised 10-20%. Addition of Cu to malleable Fe improves physical properties. Cu stools are being used for casting steel ingots. MS (11b)

Mechanical Properties of Commercially Pure Iron (Armco type). M. ARONOVICH. *Stal,* Vol. 4, Jan. 1934, pages 74-77. (In Russian). Specimens of commercially pure iron were tested in the as-rolled, normalized, quenched, and quenched and drawn conditions. As rolled, the specimens had a proportional limit of 17.9-22.3, yield point 18.4-24.4, ultimate strength 31.1-33.6 kg./mm.^{2}, elongation 28.8-38.7%, reduction of area 69.0-82.9%, and an impact resistance on Charpy test of 10.6-19.0 kg.-m./cm.^{2} HWR (11b)

Special Foundry and Alloy Irons in 1933. J. E. HURST. *Iron & Steel Industry,* Vol. 7, Jan. 1934, pages 113-114. Nicrosilal with a typical composition of 1.8% T.C., 6.0% Si, 18.0% Ni, 2.0% Cr, 1.0% Mn shows high resistance to scaling or oxidation. This alloy together with Ni-resist possesses excellent welding properties. Alloy cast irons suitable for hardening and tempering purposes are Ni-Cr, Cr-V, or Cr-Mo irons. Improved resistance to wear has been shown for "Nitricast" iron or Al-Cr alloy cast iron suitable for nitrogen hardening. Heavy duty cast irons of "Ni-tensile" or Meehanite type are in use. CEJ (11b)

Wear Tests on Cylinder Liners (Verschleissversuche an Zylinderlaufbüchsen). P. A. HELLER. *Zeitschrift Verein deutscher Ingenieure,* Vol. 78, May 12, 1934, pages 591-592. Tests to determine the wear of material used for cylinders or cylinder linings of combustion motors were made under actual operating conditions. Of the 4 materials investigated, gray Fe as cast, Cr-gray Fe oil-refined, Cr-Ni gray iron oil-refined, and gray iron refined and nitrided, the last material is by far the best. Wear ceased to increase after 10-20000 km. while it was still going on in the others after 40-50000 km. The Brinell hardness of the materials, in the order named, was 238, 488, 502, 1050 respectively. Ha (11b)

Dynamic Properties of Steel Castings. FRED GROTTS. *Transactions American Foundrymen's Association,* Vol. 5, Apr. 1934, pages 538-553. Data presented to support view that impact tests give more reliable information on the ability of cast steels to resist shock in service than do tensile tests. Type of inclusions, grain refinement and proper distribution of ferrite as shown by micrographs may correlate with impact values. No relation appeared between the values for tensile strength, elongation or Brinell hardness and impact values. Some correlation may exist between yield point, reduction of area, or fatigue resistance and impact values. Heat treatment is of special importance. Many so-called mysterious failures encountered in service are caused by lack of impact strength. CEJ (11b)

New Development in Electrical Strip Steels Characterized by Fine Grain Structure approaching the Properties of a Single Crystal. N. P. GOSS. *American Society for Metals,* Preprint No. 30, 1934, 21 pages. Describes development of new electrical strip steel which is fine grained, but through manipulation of hot rolling, heat treatment and cold rolling possesses single crystal properties. The fine grains are distributed entirely at random and magnetization curves show the same symmetry and magnitude as single crystals of the metal. WLC (11b)

Effect of McQuaid-Ehn Grain Size on Hardness and Toughness of Automotive Steels. H. W. MCQUAID. *American Society for Metals,* Preprint No. 16, 1934, 19 pages. Data are presented on the tensile strength of the case of carburized S.A.E. 1020, 2315, 4615, 2512, 3115, and 6115 as determined in transverse bend test showing greater strength for fine grained steel. Value of fine grained steels in making direct quench from carburizing possible is noted. Application of grain size specifications to various types of work is discussed and recommendations tabulated. WLC (11b)

Cold-Deformation and Treatment of Alloy Steels for the Manufacture of High-grade Precision Bolts and Their Use in Automobiles (Kaltverformung und Vergütung von Edelstählen in bezug auf die Herstellung hochwertiger, vergüteter Präzisionsschrauben und deren Verwendung im Leichtbau). KARL SCHIMZ. *Automobiltechnische Zeitschrift,* Vol. 37, May 25, 1934, pages 275-277. By using the latest knowledge of conditioning alloy steels by cold-deformation, bolts and screws for automobiles were standardized and the following properties obtained

Material	Minimum Elastic Limit kg./mm.^{2}	Tensile Strength kg./mm.^{2}
StC 35.61	33.0	55/65
VCN 15 h	52.5	75/85

Ha (11b)

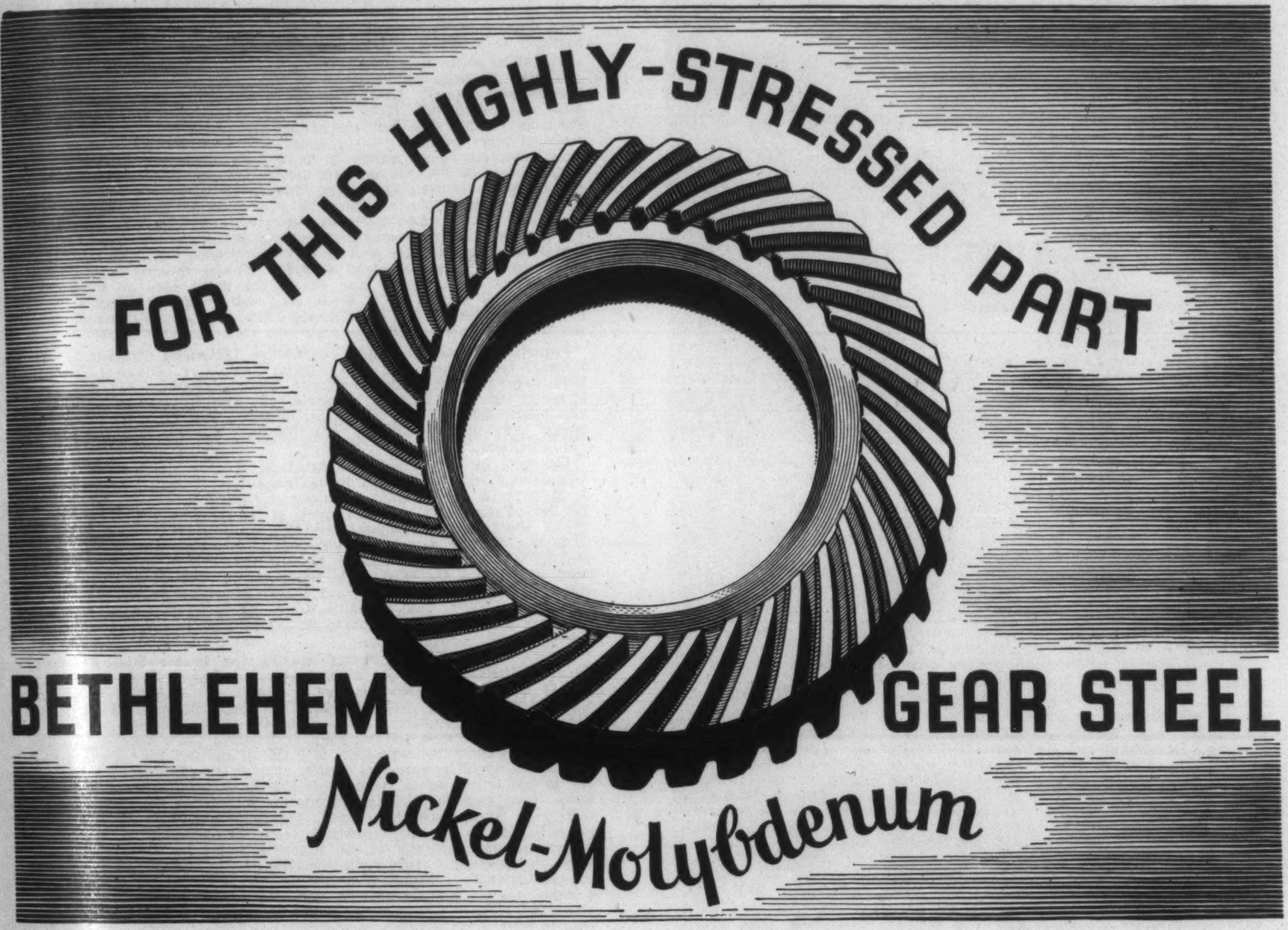
Effect of Thickness and Composition on Separately Cast Cast Iron Specimens (Die Wandstärkenempfindlichkeit getrennt gegossener Gusseisenproben und ihre Beziehung zur chemischen Zusammensetzung). P. A. HELLER & H. JUNGBLUTH. *Archiv für das Eisenhüttenwesen,* Vol. 8, Aug. 1934, pages 75-82. In separately cast specimens of cast Fe of circular cross-section, the tensile strength decreased exponentially with increasing thickness of section. The effect of thickness of section increased with increasing C+Si content. Similar results were obtained for transverse bending strength. SE (11b)

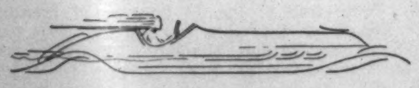
The Magnetic Properties of Cast Iron (Die magnetischen Eigenschaften des Gusseisens). E. SÖHNCHEN. *Archiv für das Eisenhüttenwesen,* Vol. 8, July 1934, pages 29-36. Contains a large amount of data on the magnetic properties of carbon and alloyed cast Fe. Finely divided graphite gives a higher coercive force than coarse graphite; the higher the ratio of graphitic to combined C the lower the coercive force and the higher the permeability. Ni additions improve mechanical properties without materially changing magnetic properties. High Ni and Mn give a useful non-magnetic iron. P is without effect. Al in small amounts causes magnetic softening; in larger amounts, hardening; Cr causes magnetic hardening. SE (11b)

Alloy Steels—Their Properties and Use. W. H. HATFIELD. *Iron & Steel Industry,* Vol. 7, Jan. 1934, pages 129-133. Alloy steels have replaced ordinary C steels in numerous branches of engineering. Increased hardness and tensile strength may be attained by careful alloying and heat-treatment. W, Co, Mn, V, Cr and Ni, usually in association with high C, are introduced singly or in combination for purposes in which high hardness is necessary. Ni-Cr case-hardening steel and Cr-Al steel of the "nitralloy" type are applicable in parts requiring maximum resistance to wear. Stainless steels of the high Cr or high Cr-Ni type with additions of W and Si are available. CEJ (11b)

General Relations Between Grain-Size and Hardenability and the Normality of Steels. E. S. DAVENPORT & E. C. BAIN. *American Society for Metals, Preprint* No. 18, 1934, 43 pages. The rate of transformation of austenite to pearlite at any temperature in ordinary medium or high C steel is related to grain size of austenite. Greater grain boundary area of fine grained austenite provides more transformation centers than coarse grained austenite resulting in less undercooling for a given rate of cooling; fine grained steel thus possesses lower hardenability. After solution of the carbide a uniform grain size is quickly established; if coarse, it will not coarsen much more, but if fine it may undergo grain growth at some higher temperature. The restraint of initial grain growth is thought to be due to dispersed particles of minute size, either non-metallic or special carbides and the more effective these particles are the higher the temperature required for grain growth in the austenite. These particles, as well as grain boundaries, act as transformation centers of the austenite upon cooling; thus the cause of fine grained condition as well as the condition itself cooperate to produce shallow hardening. The transformation products of fine grained austenite are tougher than those of coarse grained austenite. Abnormality of structure is caused by high carbon diffusivity relative to initial reaction rate and is most pronounced in nearly pure Fe-C steels having fine grain size. WLC (11b)

Directional Properties in Rolled and Annealed Low Carbon Steel. ARTHUR PHILLIPS & H. H. DUNKLE. *American Society for Metals Preprint* No. 24, 1934, 8 pages. Report of the directional properties in hot rolled, cold rolled and annealed steel of C 0.09, Mn 0.40, P 0.008, S 0.028%. Hot rolled strip consisted of 7" strip in four thicknesses, 0.053", 0.065", 0.079" and 0.103" which were all cold rolled to 0.032" and annealed at 680°, 705°, 720°, 745° C. Tensile tests were made at angles of 0°, 22.5°, 45°, 67.5° and 90° to direction of rolling. In case of smaller size hot rolled strip a slight increase in transverse as compared to longitudinal strength was noted together with a decrease in elongation. In cold rolled sheet the maximum strength was found at 90° to direction of rolling for all four amounts of reduction, 40%, 50%, 60%, and 69%. Annealed cold rolled strip showed tendency in the case of heavier reductions, to reach a maximum strength at 45° instead of 90° to direction of rolling. Comparison is made with similar studies on Cu. WLC (11b)





FEW PARTS have to meet demands as severe as those encountered by automobile ring-gears. Steel for ring-gears must combine great strength and high shock resistance, to stand the stresses encountered in use, with easy machining and uniform heat-treating properties to facilitate production.

In perfecting Bethlehem Nickel-Molybdenum Gear Steel untold effort has been devoted to the development of melting practice that will turn out consistently, heat after heat, gear steels that measure up to exceptionally high standards in respect to all of these points. Of course, close adherence to the customer's specifications and cleanliness of the steel are fundamental, and taken for granted. But beyond these basic factors are other properties, less easily specified or controlled, that the melter must keep in line by the exercise of highly-developed "steel-making sense."

Ability to do this has come as the natural outgrowth of years of close liaison, maintained by alert metallurgists, between the customer's plant and the open-hearth furnaces.

The result is that in tooth strength, in machinability, in uniform heat-treating characteristics, in freedom from warpage, Bethlehem Nickel-Molybdenum Gear Steel is outstanding. It is used in the ring-gears and pinions of many of today's motor cars.

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BETHLEHEM *Fine* ALLOY STEELS

EFFECT OF TEMPERATURE ON METALS & ALLOYS (12)

L. JORDAN, SECTION EDITOR

The abstracts in this section are prepared in coöperation with the Joint High Temperature Committee of the A.S.M.E. and the A.S.T.M.

Prevention of Crusting on Boiler Safety Plugs. H. N. BASSETT. *Mechanical World & Engineering Record,* Vol. 95, Mar. 23, 1934, pages 275-276. Causes of the failure of safety plugs are dealt with. The common cause is the formation of scale and the "picking up" of Cu, both of which raise the melting point. Analyses of different scales are tabulated and discussed. It is advisable to use a bronze for the body of the plug containing as little Zn as possible to avoid the absorption of Zn by the Sn filling. The absorption of Cu is important, because Cu up to 1% reduces the melting point of the Sn filling, but any Cu in excess of this causes a considerable rise in the melting point. It is therefore necessary to pour at as low a temperature as possible. The bores of the plugs should be well tinned before filling. Kz (12)

Erection of High-Pressure Steampipes. H. C. YOUNG. *Mechanical World & Engineering Record,* Vol. 95, May 18, 1934, pages 473-474. Abstract of a paper, "Some Power Plant Erection Problems," presented to the Manchester Association of Engineers. Deals with the selection and method of application of bolts to insure steamtight joints. Discussion of creep rates of alloy and mild steels at elevated temperatures. To withstand the effect of creep it is necessary to use alloy steel bolts and strain them equally. Kz (12)

Creep Resistance of Structural Steel and a Simplified Testing Method (Dauerstandsfestigkeit von Baustahl und ihre vereinfachte Ermittlung). HUBERT JURETZEK & FRANZ SAUERWALD. *Die Wärme,* Vol. 57, Apr. 28, 1934, pages 267-273. 7 structural steels of the plain C and low alloy type (analyses given) were subjected to creep tests at 400°, 500° and 550°C. for several hundred hours. The creep resistance was found to increase with rising C contents and was higher with alloy steel than with plain C steel. A steel containing 0.34% Mo (.155% C) showed the remarkable creep strength of 9 kg./mm.^{2} at 550°C. Cast steel with .30 C, .64 Mn, .41 Si showed the same properties as a low-C steel of .115 C, .48 Mn at 400°C. but displayed superior properties at higher temperatures. This behavior is ascribed to the Si content. The main object of the experiments was the development of a simplified creep test equipment which requires only 1 test bar submitted to gradually increasing loads. The authors show that the results of their short time test coincide with previous results from long time creep tests. Immunity to creep is defined by a limit of $1 \times 10^{-4}\%$ elongation/hr. 9 references. EF (12)

Strength and hardness of different aluminum alloys at elevated temperatures (Warmfestigkeit und Warmhärte verschiedener Aluminiumlegierungen). A. V. ZEERLEDER, BOSSHARD AND IRMANN. *Zeitschrift für Metallkunde,* Vol. 25, Dec. 1933, pages 293-299. The modern use of Al alloys at temperatures from 200-300°C. requires accurate knowledge of their behavior at these temperatures; many results in the literature are of little use because of inadequate specification of previous history, heat treatment, and details of measurement. Measurements are given here of yield point, tensile strength, elongation, Brinell hardness of 3 varieties of "pure Al" for conductor wires, 6 casting alloys, and 4 forging alloys over a temperature range from room temperature to 400-500°; similar data are given showing the effect of stabilization and time of heating. These data are reproduced in 13 graphs. With discussion. RFM (12)

Growth of Gray Cast Irons. THOMAS J. WOOD. *Iron Age,* Vol. 132, July 13, 1933, pages 12-13. **Growth of Cast Irons at High Temperatures.** *Iron Age,* July 27, 1933, pages 12-14. **Castings that Keep Strength and Shape at High Temperatures.** *Iron Age,* Aug. 3, 1933, pages 30-32. Includes a bibliography of 58 references. Gives results of investigations by the International Nickel Co., on the causes of growth in castings. Growth can take place at sub-critical temperatures and at super-critical temperatures. Series of plain and alloyed cast irons were exposed within superheated steam line operating at an average of 900° F. Alloyed irons were superior to plain Fe. Below the critical temperature the stability of combined C is a function of Si content. Low Si, Ni-Cr cast iron displayed exceptional resistance to structural deterioration in these tests. At temperatures above the critical transformation range the atmosphere in which heating takes place has marked effect upon the extent to which growth occurs. Compositions resistant to growth in oxidizing atmospheres may be made gray and machinable by addition of sufficient amount of Ni. Combination of Ni and Cr is also useful for retarding growth. For resistance to growth in reducing atmosphere it is necessary to have either a well-dispersed graphite flake formation or a matrix which does not tend to "crack" the gas to form free C. VSP (12)

Allowing for Creep in Turbine Parts. A. G. S. BROWN. *Mechanical World & Engineering Record,* Vol. 95, May 4, 1934, pages 427-428. Abstract of a paper, "Limiting Factors in the Development of the Turbine," presented to the Rugby Engineering Society. Properties of materials used for turbine parts which have to withstand high pressure at elevated temperature and permissible creep rates for these parts are discussed. The effect of creep on various turbine parts is dealt with. A table shows the relative strength of mild steel, Ni-Cr, Ni-Cr-Mo, Cr-V, Cr-Si, and austenitic stainless steels at elevated temperatures. The percentage of Ni in Ni-Cr steels can be reduced to a minimum as it contributes very little to the creep-resisting properties of the alloys. Ni-Cr-Mo steel gives good results up to 500°-550°C. and the addition of Mo without Ni or Cr improves the strength of steel considerably at high temperatures. Research work has lately been carried out on low-carbon steel containing 0.1-0.2% C and 0.3-0.4% Mo. Kz (12)

The Ductility of Chromium-Nickel Austenitic Steels at Elevated Temperatures. H. D. NEWELL. *American Society for Metals Preprint* No. 25, 1934. 19 pages. Data presented show the effect of various special elements and composition variation on the ductility of Cr-Ni austenitic steels at elevated temperatures as measured by short time tensile tests. Factors affecting hot ductility are formation of ferrite, deoxidation effects produced by added element, grain refinement produced, and effect of added element on carbide stability and distribution. Elements tending to form ferrite improve hot ductility but their deoxidizing power and grain refining action are more potent. Si is an exception as it promotes hot ductility in the absence of ferrite. From the fact that low alloy steels show poor hot ductility in the region of the transformation to γ Fe it is concluded that the non-ductile quality of these steels is associated with the austenitic nature and that the production of an austenitic steel having hot ductility approaching that of α Fe is improbable. WLC (12)

Influence of Grain-Size on the High Temperature Characteristics of Ferrous and Nonferrous alloys. A. E. WHITE & C. L. CLARK. *American Society for Metals Preprint* No. 15, 1934, 20 pages. Data are presented showing the effect of McQuaid-Ehn (inherent) grain size and actual grain size of two low-C steels, (0.50% Mo, and 1.25% Mn with 0.25% Mo) on the tensile, Charpy and creep values at room temperature, 800°, 1000° and 1200° F. Cu-Zn-Sn alloys (77-22-1 and 59-40-1) were tested at room temperature and 300° and 600°F. It is indicated that actual grain size has an influence upon high temperature tensile properties, fine grained material showing greater strength over entire range considered. The influence on ductility is not uniform but coarse grained material tends to give greater elongation while fine grained gives greater reduction of area. Creep tests indicate that below the lowest temperature of recrystallization fine grained material has the greater resistance to creep; above that temperature coarse grained material has the greater resistance to creep. WLC (12)

A Low Alloy Rail for Arctic Railroads. E. H. SCHULZ. *Metal Progress.* Vol. 26, July 1934, page 48. Describes the properties of new low alloy steel (less than 0.2%C) made in basic Bessemer converter which shows improved resistance to impact at subzero temperatures. WLC (12)

The Study of the Resistance of Steels to Corrosion at High Temperatures (Quelques Idées Générales sur l'étude de la Résistance des Aciers à la Corrosion aux Températures Elevées). HOUDREMONT. *Chaleur et Industrie,* Vol. 15, Mar. 1934, pages 150-158. Paper read at the 3rd Congress of Industrial Heating, Paris, Oct. 1933. The best method for determining the corrosion resistance of steels at high temperature is by actual service. There are, however, laboratory tests which may prove useful. It is difficult to measure the oxidation rate. Weight losses do not give sufficient information and it is necessary to consider the appearance of corroded samples. Results of laboratory tests do not always agree with those of practice. Elements more oxidizable than Fe are Si, Mn, Al, Ti, Zr, V, W, etc. Less oxidizable elements are Ni, Co, Cu, Mo. Elements of the first series are often used to alloy with Fe because the kind of oxide layers formed by oxidation plays a large part in corrosion resistance. It is for this reason that Cr is a very useful alloy for corrosion resisting steels. Apart from Ni, elements less oxidizable than Fe are not widely used as alloying elements. The effects of CN, N, H, S, S+0, etc., and of alloying elements on corrosion resistance to these media, are discussed. The corrosion resistance of steels is a very complex matter requiring the study of a great number of factors. FR (12)

Properties of Materials at High Temperatures (Propriétés Générales des Matériaux à Hautes Températures). H. J. TAPSELL. *Science et Industrie,* Vol. 18, Apr. 1934, pages 106-110. Article deals with following subjects. (1) Speed of testing in tensile test. (2) Plasticity of metals. (3) Plasticity changes with temperature. (4) Plastic deformation as a function of time. (5) Plasticity characteristics of metals. (6) Negative sliding. (7) Ductility changes. Intercrystalline cracks. (8) Brittleness. FR (12)

Equipment for Testing and Flow Resistance of some Steels at High Temperature (Appareillage pour les Essais à Haute Temperature et Resistance à l'Ecoulement). I. MUSATTI & A. REGGIORI. *Chaleur et Industrie,* Vol. 15, Mar. 1934, pages 247-262. Paper read at the 3d Congress of Industrial Heating, Paris, Oct. 10-14, 1933. Description of equipment used by the authors in their tests is given. Tests were made on 6 types of alloy steels at temperatures of 500°, 600°, 700° and 800°C. Austenitic steels with high Cr and Ni and some Si and W behaved much better than the other steels tested at the highest temperatures. A steel containing Ni 10, Cr 4, W 20 had a lower resistance at 500°C. but a higher resistance at 800°C. than austenitic steels. Owing to its low content of Cr this steel was much more susceptible to scaling at high temperatures than austenitic steels. FR (12)

Thermal Autostabilization Method and its Use in the Study of Some Heat Resisting Steels (La Méthode d'Autostabilisation Thermique et son Utilisation à l'Etude de Quelques Aciers Résistant à chaud). G. RANQUE & P. HENRY. *Chaleur et Industrie,* Vol. 15, Mar. 1934, pages 222-237. Paper read at the 3rd Congress of Industrial Heating, Paris, Oct. 1933. Method described consists essentially of a tensile test in which is measured, as a function of time, the temperature insuring the permanence of length of the test bar. The bar itself acts through its reversible changes of expansion as an automatic dilatometric regulator. The method is adapted to the study of the properties of metals at high temperatures. Tests made have led to conclusions supplementing the ideas of White and Clark; (1) When a steel has a single phase stable structure or when the second phase is inactive (globular condition), creep is influenced by the equicohesive temperature and grain size in the manner indicated by White and Clark. (2) Below the equicohesive temperature the resistance to flow can be increased during the test either by a hardening of the material of the grains or by precipitating a stable, harder constituent in the grain boundaries. (3) The resistance to flow of a steel above the equicohesive temperature can be increased if it is possible, prior to the test, to distribute in the grain boundaries a constituent which is stable at the test temperature. FR (12)

Testing Methods for Steels at High Temperature (Considérations sur les Méthodes d'Essai des Aciers à Haute Température). H. DUSTIN. *Chaleur et Industrie,* Vol. 15, Mar. 1934, pages 201-210. Paper read at the 3d Congress of Industrial Heating—Paris, Oct. 10-14, 1933. Report of the work of "Comité Belge pour l'étude du comportement des métaux aux températures élevées." Eliminating consideration of corrosion, the causes of failure of metal parts at high temperature are (1) excessive plastic deformation, (2) intercrystalline fracture without deformation, (3) structural modifications, (4) aging phenomena. The procedure in making creep tests in the author's laboratory is as follows: Temperatures at which creep tests are made are first roughly selected. Then preliminary tests of about 50 hours duration are made to determine the loads which will permit tests of 200-500 hour duration. The author states that his Brussels laboratory works in close coöperation with National Physical Laboratory and Kaiser Wilhelm Institute. FR (12)

Contribution to the Development of Heat Resisting Alloys (Contribution au Développement des Alliages Résistants à la Chaleur). E. PIWOWARSKY. *Chaleur et Industrie,* Vol. 15, Mar. 1934, pages 159-166. Paper read at the 3rd Congress of Industrial Heating, Paris, Oct. 1933. See *Metals & Alloys,* Vol. 5, July 1934, page MA 361. FR (12)

Electrical Phenomena at Low Temperatures. J. C. McLENNAN. *Electrical Review,* Vol. 114, May 4, 1934, page 630. Abstract of Kelvin lecture delivered before the Institution of Electrical Engineers, Apr. 1934. See "Electric Supra-Conduction in Metals," *Metals & Alloys,* Vol. 5, Feb. 1934, page MA 37. MS (12)

Steel for Pressure Plant. Effect of Hydrogen at High Temperatures. *Chemical Trade Journal & Chemical Engineer,* Vol. 93, Sept. 29, 1933, page 230. Abstract of a paper on the action of H_2 on steel at high temperatures and pressures, presented by N. P. Inglis and W. Andrews before the Iron and Steel Institute at Sheffield. See "Effect on Various Steels of Hydrogen at High Pressures and Temperatures," *Metals & Alloys,* Vol. 5, June 1934, page MA 290. JN (12)

Oxidation of a Low Carbon Steel in the Temperature Range 1650 to 2100 Degrees Fahr. CLARENCE A. SIEBERT & CLAIR UPTHEGROVE. *American Society for Metals Preprint* No. 3, 1934, 30 pages. Data are presented on the effect of temperature, time and partial pressure of O_2 on the scaling of S.A.E. 1020 steel in the range 1650°-2100° F. A decrease in the amount of scaling with increasing temperature occurs for all concentrations of O_2 in range considered. The ferrous iron content of scales formed undergoes a similar reversal. The reversal occurs for all periods of time up to 6 hours. Effect of increasing time on scaling in atmospheres of O_2, air and 13% O_2 is in general the same whether the temperature is one at which scaling is increasing with increasing temperature or not. Fe^{++} content of the scale is found to decrease for temperatures which show the greatest retardation of rate of scaling with increase in time. For temperatures which show less falling off in scaling the Fe^{++} content of scales is found to increase with time. For certain O_2 concentrations retardation of scaling with increasing temperature may occur without change in the degree of oxidation. A theory is advanced for the reversal in the temperature-loss in weight curves in the range 1800° to 2100° F. 13 references. WLC (12)

The Relation of Temperature to the Hardenability of a Brass (Über die Temperaturabhängigkeit der Verfestigungsfähigkeit von α-Messing). F. SAUERWALD & H. GIERSBERG. *Zeitschrift für Metallkunde,* Vol. 26, June 1934, page 135. A continuation of a previous investigation (*Archiv für das Eisenhüttenwesen,* 5, 1929) in which measurements are made of the hardness of specimens quenched after being struck with a drop hammer at temperatures of 0°-700°C. The work hardening is constant up to 500°C. after which it decreases to none at 700°C. The relation between temperature and work of deformation is irregular. FNR (12)

CORROSION & WEAR (13)

V. V. KENDALL, SECTION EDITOR

Basic Studies of Wear in a Spindel Machine (Grundsätzliche Untersuchungen des Verschleisses auf der Spindel-Machine). W. Eilender, W. Oertel & H. Schmalz. *Archiv für das Eisenhüttenwesen,* Vol. 8, Aug. 1934, pages 61-65. In wear tests of 0.1 to 1.75% C steels on a Spindel machine, the wear became proportioned to the length of the wear path only after 100 meters of wear path. With increased speed the wear rose to a maximum, then decreased to a minimum as a result of cold work; this was followed by a slow rise in wear. Change in pressure had a similar effect. Wear-speed curves for a 200 meter run under 8 kg. load were used for comparing different materials. Wear decreased with increasing hardness and grain size. Lamellar pearlite gave less wear than spheroidized cementite. Retained austenite reduced the wear to a minimum at 15 to 20% retained austenite; with more than that the wear increased again. Ni, Cr, W, Mn, additions reduced the wear, especially Mn; V and Co had only a small effect in reducing wear. SE (13)

Numerical Results Obtained with Chemical Methods of Pickling Light and Ultra-Light Metals after Corrosion (Résultats numériques relatifs aux méthodes chimiques de décapage des métaux légers et ultra-légers après corrosion). Marcel Chaussain & Henri Fournier. *Revue de Metállurgie,* Vol. 31, May 1934, pages 201-211. In most corrosion work the corroded specimens are cleaned by dissolving the deposits formed. For aluminum alloys concentrated nitric acid is used, for magnesium alloys solutions of chromic acid. The amount of the base metal dissolved by them was determined as a function of the concentration of acid, of the temperature and of time. For aluminum acid attack at 35° C. is 1.5 gr/m^2, at 85° C. 14.1 gr/m^2. Acid dilution brings the attack to a maximum at about 40% concentration. A 10% solution attacks at the same rate as concentrated acid, but the character of the surface produced is different. The dissolution of Al is proportional to time. Figures are given for the ranges covered. A method is proposed for elimination of the influence of the base metal dissolved. Corroded specimens are pickled for a definite time under definite conditions, dried, weighed and re-pickled for the same time and under the same conditions as before. The second weighing permits the determination of the acid attack on the base to be discounted in the determination of the degree of scaling. Removal of corrosion products from Mg and its alloys can be made with boiling 15% solution of CrO_3 freed from the traces of Cl by addition of 1% Ag_2CrO_4. A series of experiments with two different CrO_3 solutions showed the detrimental effect on passivation of traces of H_2SO_4. An addition of 1% $BaCrO_4$ to the solution containing 1% Ag_2CrO_4 of any commercial CrO_3 neutralizes the action of H_2SO_4 producing uniform passivation and completely removing the products of corrosion. JDG (13)

On the Behavior of Steel Tubes to the Action of Corrosive Agents (Ueber das Verhalten von Stahlröhren bei Einwirkung von aggressiven Stoffen). *Montanistische Rundschau,* Vol. XXVI, July 16, 1934, (Section *Stahlbau-Technik*), page 2. Heinrich Rosenberg discusses article under the above title which appeared in the May 16, 1934 issue (See *Metals & Alloys,* Vol. 5, Aug. 1934, page MA 419), stating that very good protection of seamless steel tubes may be obtained by painting them with a mixture of 70% blown asphalt and 30% Mikro-Asbest. This forms a layer having practically the same thermal expansion as the steel itself. BHS (13)

Double Acting Engine Piston Rods. Heinrich Becker. *The Motor Ship.* Vol. 15, May, 1934, pages 57-59. An analysis of the causes of failure in piston rods shows that alloy steel is more liable to crack at the threads than open-hearth steel. Cracks at the point of maximum heat stress are also developed earlier in alloy steel than in open-hearth steel under similar condition, but only when corrosion is a predisposing cause. The results of testing the effects of fresh water and sea water in their relation to corrosion effect with alternations of load on C steel and Cr-V steel to the extent of 100,000,000 are also given. JWD (13)

The Behavior of Colored Zinc Sheet in the Alternate Immersion Corrosion Test (Das Verhalten gefärbter Zinkbleche bei Wechseltauchbeanspruchung). W. Beck & E. Völker. *Zeitschrift für Metallkunde,* Vol. 26 Mar. 1934, pages 56-61. Zn sheets were etched, dried, and colored, and then subjected to alternate immersion in a corrosive bath of aqueous 5% NaCl with 0.1% H_2O_2. Immersion was 2 or 7 min. in the bath and 58 or 57 min. in air. The coloring was obtained by 30 min. immersion in a strong $FeCl_3$ solution; by 15 min. immersion in an ammonium molybdate solution; by immersion in ammoniated solution of Cu salts; by immersion in Mn salt solutions; and by immersion in a chlorate solution. These solutions develop the most beautiful colors on Zn. Curves are given showing the weight loss of the Zn sheet upon corrosion, both colored and uncolored; and a photograph shows the appearance of the sheet after free air corrosion. In both free air and the corrosive solution the Mn colored sheet shows the most improved corrosion resistance. Details in the coloring process are given. RFM (13)

The Corrosion of Electrolytic Zinc and Refined Zinc (Über die Korrosion von Elektrolytzink und Raffinadezink). O. Baur & G. Schikorr. *Zeitschrift für Metallkunde,* Vol. 26, Apr. 1934, pages 73-80. Two samples of refined Zn (R_1,—1.1% Pb, 0.017% Cd, 0.001% Cu, 0.012% Fe, 0.006% Sn + Sb, 0.0008% Bi; R_2,—0.97% Pb, 0.010% Cd, 0.003% Cu, 0.008% Fe, 0.007% Sn + Sb, 0.0008% Bi) and one sample of electrolytic Zn (E,—.015% Pb, 0.0008% Cd, 0.0005% Cu, 0.003% Fe) were studied, all in sheets 0.6 mm. thick. The corrosion of these samples was studied under the following conditions: (1) attack by water, both still and repeated immersion, (2) attack by acid solution, (3) attack by alkaline liquids, (4) atmospheric attack, (5) attack by plaster of paris and cement in the presence of moisture, (6) attack by wood in the presence of moisture. The data are given in a series of curves and tables. These show that E is attacked less by neutral water than R, and that CO_2 leads to the production of a protective film; that in acid solutions, where H is developed, E in general dissolves more rapidly than R; that in alkaline solutions (soda, etc.) no appreciable difference obtained; that no appreciable difference obtained in atmospheric corrosion; that atmospheric attack was least in rural regions and greatest in the neighborhood of acid fumes; damp plaster of paris is more corrosive than damp cement, and E is somewhat more rapidly attacked; linden wood is more corrosive than beech, and R is more rapidly attacked than E, though pine attacks E more strongly than R. RFM (13)

Treatment of Metal Parts to Prevent Rusting. *Machinery,* London, Vol. 43, Mar. 22, 1934, page 745. Bath made up from 1.1 pints of phosphoric acid, 2 lbs. of black oxide of manganese, 70 gallons of water. Ingredients must be well mixed, bath brought to the boiling point. Parts have to be immersed in the boiling solution for 2 hours. The greenish deposit on the surface can be brushed off. It is claimed that parts so treated may be assembled without fear of rusting. When painted no rust will form beneath the paint. Treatment is said to give protection against chemical fumes. Kz (13)

Protective Painting of Metal Work. S. C. Britton & U. R. Evans. *Iron Age,* Vol. 132, Oct. 5, 1933, pages 23, 68. Abstract of paper read before the Electrochemical Society. Life of painted metal work depends on 4 variables: (1) Nature of metal; (2) Presence of separating matter between metal and paint; (3) Character of paint; and (4) Character of the atmosphere, water or soil to which painted metal is exposed. Gives a summary of the effects of the 4 variables as shown by results of authors' tests. See also "Practical Problems of Corrosion," *Metals & Alloys,* Vol. 4, Aug. 1933, page MA 271. VSP (13)

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The CORROSION RESISTING ALLOY

Cylinder Wear. *Automobile Engineer*, Vol. 24, June 1934, page 229. The record of a prolonged test in service of centrifugally cast cylinder liners is given in a chart showing mileage, oil consumption and average cylinder wear over a period of 2 years. The liner analysis is: 0.75% total C, 0.6-0.8% combined C, 2-2.4% Si, 0.08% S, 0.8% P, 0.8-1.2% Mn; tensile strength 16 tons/in². The average wear after 2 years was 0.006 in. Ha (13)

The Influence of Oxide Films on the Wear of Steels. SAMUEL J. ROSENBERG & LOUIS JORDAN. *American Society for Metals Preprint* No. 26, 1934, 22 pages. Wear tests in an Amsler machine on specimens of hypo-, hyper-, and eutectoid steels are reported indicating that rates of wear of all steels in air are low and worn surfaces smooth and covered with oxide films, that rates of wear of steel tempered at low temperatures tested in O_2 atmosphere are also low and surfaces smooth and filmed with oxide of lighter color than air tested specimens, that rates of wear of steels tempered at higher temperatures in O_2 free atmosphere are high and surfaces very rough and free from film, and that under certain conditions the absence of O_2 is conducive to greatly increased rates of wear. WLC (13)

Some Optical Observations on the Protective Films on Aluminium in Nitric, Chromic and Sulphuric Acids. L. TRONSTAD & T. HOVERSTAD. *Transactions Faraday Society*, Vol. 30, Mar. 1934, pages 362-366. 10 references. In chromic acid and chromate-chloride solutions, only small changes in the optical properties of the natural oxide film on Al were observed. In concentrated H_2SO_4, the films were not protective. In nitric acid an alternate formation and breakdown of protective film occurred. Approximate thickness of films on Al was calculated. Maximum mean thickness 300 A.U.; natural film 110-130 A.U. PRK (13)

Some Optical Observations on the Passivity of Iron and Steel in Nitric and Chromic Acids. L. TRONSTAD & C. W. BORGMAN. *Transactions Faraday Society*, Vol. 30, Mar. 1934, pages 349-361. 11 references. Mirrors of iron steel and stainless steel in solutions of HNO_3, H_2CrO_3, and of $KCrO_4$ and KCl were measured by the optical method of Drude. The results, given in form of graphs, indicate that an oxide film is present when the metals are immersed in HNO_3 or H_2CrO_3 solution. Natural films are strengthened or replaced with denser films. The mean thickness of the oxide or passive film on steel in concentrated HNO_3 was about 100 A.U., on iron and steel in H_2CrO_3 or $KCrO_4$ + KCl about 30-40 A.U., on stainless steel about 10 A.U. PRK (13)

Report of Subcommittee IV on Methods of Corrosion Testing (Report of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys). W. R. HUEY, Chairman. *Proceedings American Society Testing Materials*, Vol. 33, Pt. I, 1933, pages 178-208. The purpose of this investigation was to determine the extent of agreement in data obtained by several laboratories following carefully prescribed test procedures. Samples of three commercially important alloys (13% Cr, 17% Cr and 18-8 CrNi) were supplied to 15 industrial and institutional laboratories for test by the salt-spray, boiling nitric acid and the copper sulphate stain tests. The conclusions were as follows. (1) Neither the salt spray test nor the copper sulphate stain test may be considered as quantitative, nor its results reproducible in the same or different laboratories. The data from both of these tests are likely to be erratic. Hence, no important decision should be based on the data, concerning the suitability of an alloy for a given service or the quality of a particular sample of an alloy. (2) The boiling nitric acid test is capable of furnishing accurate, reproducible, quantitative data. This test may be used to determine the quality of alloys such as those tested and reported upon herein. It should be noted that within reasonably broad limits this may be true regardless of the service conditions to which the alloys are to be subjected. VVK (13)

Enamelled Parts for Well Pumps. SHELDON N. FLOHR. *Canadian Engineer*, Vol. 66, Mar. 6, 1934, pages 15-16. Tests of deep-well turbine pumps having porcelain enamelled parts compared with the conventional materials demonstrated a three- or four-fold life for the former over the latter under very severe service conditions. The advantages of the former are: increase in efficiency due to lower friction losses in the pump, maintenance of this higher efficiency over a longer period of time under a given pumping condition due to resistance to abrasion, and action of the porcelain coating as an insulator against oxidation and electrolysis and its resistance to acids. VVK (13)

Corrosion in Non-Pressure Refining Equipment. S. S. SHAFFER & J. E. POLLOCK. *Refiner & Natural Gasoline Manufacturer*, Vol. 11, Nov. 1932, pages 568-572; *Oil & Gas Journal*, Vol. 31, Nov. 17, 1932, pages 88-90. American Petroleum Institute Meeting Nov. 1932. Corrosion in non-pressure refining equipment is divided into tanks, lines, stills and condensers. Detailed attention is given the use of ammonia for preventing corrosion in condensers. The use of approximately 3 lbs. ammonia per 1000 bbls. of crude will reduce iron losses by 80 to 90%. VVK (13)

Hard-Facing, Inserts and Plating Satisfy Hardness Requirements. ALLEN F. CLARK. *Machine Design*, Vol. 6, May, 1934, pages 27-30. Welding-on of abrasion resistant alloys is shown by practical examples. A table summarizes 16 commercially important hard alloys, their composition, field of application, Brinell hardness as deposited by oxy-acetylene and arc welding, and their peculiar properties. Cases where hard-facing should be dismissed are discussed critically. Only passing mention is given to the W carbide group, while Fe-base alloys containing Cr, W, Mn, Si, Co, Ni are stressed. WH (13)

Choosing Coatings To Preserve Metal. H. S. RAWDON. *Steel*, Vol. 94, May 21, 1934, page 30. Abstract of paper read before the Detroit Chapter, American Society of Metals, May 14, 1934. Reviews history of protective metallic coatings, different methods of applying them, practical uses, and methods of testing corrosion resistance. Use of coatings for protection of ferrous materials against corrosion must be governed by type of atmosphere to be encountered in service. Outdoor corrosion tests being conducted by a number of technical organizations yield most useful information relative to service value. Results so far indicate that hot-dipped galvanizing gives life under adverse atmospheric conditions. MS (13)

Rapid Method for Determining Electro-Chemical Corrosion of Welded Joints (Essais rapides de détermination de la corrosion électrochimique des assemblages soudés). ALBERT ROUX. *Comptes Rendus*, Vol. 198, June 11, 1934, pages 2095-2098. Method consists in placing two electrodes, one of weld metal and one of base metal in electrolyte and measuring direction and quantity of e.m.f. as a function of time.

Base Metal	Weld Metal	Electrolyte	Polarity of Weld	E.m.f.
Low C Steel	0.25 C; 0.1-0.8% Mn	4% H_2SO_4	Anodic	Increases with time and then is constant
Low C Steel	"	2% HCl	Anodic	Decreases with time and then is constant
Low C Steel	0.20% C; 1-2% Ni or 0.5% Cr and some Cu	4% H_2SO_4	Cathodic	Decreases with time and then is constant
Low C Steel	"	2% HCl	Cathodic	Decreases with time and then is constant
0.25% C; 0.5 to 1.2 Mn; 0.5-1% Cr; 0.5% Cu	Plain C Steel	4% H_2SO_4	Anodic	Increases and then is constant

FHC (13)

The Perkin Medal, 1933. Chemistry and Art. COLIN G. FINK. *Journal Society Chemical Industry*, Vol. 53, Mar. 2, 1934, pages 191-195, Mar. 9, 1934, pages 216-219. Methods of restoring and preserving marbles and other stones, pottery, ivories and wood, and bronzes are explained. In restoring corroded bronzes, the oxides, sulphates, chlorides and carbonates in the crust surrounding the article are reduced back to the original metal by making the object the cathode in a 2% sodium hydrate solution. The process requires considerable time. The so-called "bronze disease" is caused by the presence of chloride in the atmosphere. The atmosphere in museum cases can be kept free of moisture, H_2S, CO_2, etc., by keeping soda lime in the cases. VVK (13)

A New Protective Method for Corrosion of Al and its Alloys. MASAHIRO TAZAKI. *Tetsu to Hagane*, Vol. 20, Jan. 25, 1934, pages 42-46. (In Japanese.) A new method by which Al and its alloys are well protected from corrosion of sea water was invented. The method is anodic oxidation of the surfaces of Al and its alloys in a bath of salt mixture, KNO_3 and $NaNO_3$; the best result is obtained under the following conditions:

	Al	duralumin
Temp. of bath	220°-250°	500° ± 10°
Voltage A.C.	100 V.	65 V.
Current density	4 amp./cm.²	4 amp./cm.²
Time	1 hr.	30 min.

Corrosion tests were carried out in sea water with Al and its alloys treated by the new and other methods. The oxide film obtained by the new method showed most excellent results. Al and duralumin treated by the new method were subjected to tensile tests, which showed little decrease in strength. TS (13)

The "Eric" Process of Cleaning and Relining Water Mains. S. A. McWILLIAMS. *Canadian Engineer*, Vol. 66, June 19, 1934, pages 19-21. The Eric process consists in cleaning the main by scrapers, filling it with a special colloid solution of bitumen and depositing the bitumen by electric current through an electrode drawn through the pipe. As the bitumen is deposited it acts as an insulator and when the metal surface is covered ceases to deposit. The electrode is then moved to the next section. After returning the solution to the tank the main is flushed out and can be returned to service immediately. The process has been used in England and Scotland during the last four years with satisfactory results. VVK (13)

Underground Corrosion of Ferrous Pipe. K. H. LOGAN. *Civil Engineering*, Vol. 4, Mar. 1934, page 129. Underground corrosion of pipes, which in the oil industry of U. S. A. alone causes an estimated annual loss of $25,000,000, depends more on the characteristics of the soil than on the type of ferrous pipe materials used. Where corrosion is serious, it may be combated by deep burial, use of copper or copper alloy pipe, increasing the wall thickness (corrosion seems much slower after 4-5 yrs.), or using protective coatings. JCC (13)

Protection against Corrosion (La Lutte contre la Corrosion). L. LABIESSE. *Arts-et-Métiers*, Vol. 87, Apr. 1934, pages 74-83. Importance of corrosion is first estimated, then theories for corrosion are reviewed. It is generally accepted that at high temperatures corrosion is chiefly due to chemical action and at low temperatures to electrochemical effects. Selection of materials to resist corrosion, non-metallic and metallic protective coatings are reviewed and technical and economic characteristics of each one are discussed. Semi-corrosion-resistant metals such as Armco Fe and Apso and Durapso steels, the latter being respectively Cu and Cr-Cu steels are described. Other steels of similar type such as Toncan, Pravinox, Rombho and Durrombbo, etc., are also dealt with. FR (13)

Corrosion of Well Casings by Electrolysis. SHEPPARD T. POWELL. *Water Works & Sewerage*, Vol. 81, Apr. 1934, pages 112-114. The corrosion difficulties of underground water supplies are pointed out and methods for measuring stray currents in pipe lines explained. Installation of insulating joints and the elimination, as far as possible, of contact between dissimilar metals in the construction of wells, will prevent electrolytic corrosion. Ha (13)

Rates of Scale Formation on Iron and A Few of its Alloys. K. HEINDLHOFER & B. M. LARSEN. *Transactions American Society for Steel Treating*, Vol. 21, Sept. 1933, pages 865-895. Scaling is considered as a diffusion process. The simple case of a plane bounded pure metal capable of forming more than one oxide, hence more than one scale layer, is treated mathematically. It is shown that the thickness of each layer, hence the thickness of the whole scale increases as the square root of time and increases rapidly with rising temperature, according to an exponential relation. These simple relations are not strictly valid for alloys or for sharply curved surfaces such as wires. These conclusions are confirmed for pure iron and pure copper and a few iron alloys by experiments using relatively long periods of exposure and continuous weighing of the sample during the scaling period. Scaling of iron in water vapor and CO_2 proceeds at rates not very different from those in air or oxygen, provided sufficient time is allowed for the attainment of steady state condition. The scaling of a few resistant alloys is studied. WLC (13)

Experimental Results on Variously Pigmented Oil Base Paints Applied to Parkerized and Ordinary Steel Sheets and Subjected to Accelerated Corrosion Tests (Kurzprüfversuchsergebnisse über die Verwendung verschieden pigmentierter ölgrundierung auf phosphatiertem und gewöhnlichen Blechen). FR. KOLKE. *Farben Zeitung*, Vol. 39, Mar. 31, 1934, pages 331-334. Test results are presented in 4 tables which show the behavior of red lead, lead white, Zn white, Zn chromate, Fe oxide and Al bronze powder applied as (1) base material, (2) primer + outer coat and (3) outer coat alone on Fe sheets in the as delivered and parkerized state. Visual examination took place after 30 and 60 days exposure to a solution of 3% NaCl. The oil content of the primer was 10 and 20%. In summary it can be said that all of the coating combinations exhibited superior qualities when utilized on the parkerized sheets. The most pronounced attack occurred at the boundary line NaCl solution-air. On the phosphatized samples the coatings consisting of only a primer (1) proved to be less stable than those exclusively representing an outer coating (3). The water stability of the coatings proved to be the more inferior the higher their oil content, but this difference did not show up on phosphatized samples after 60 days. On ordinary carriers the coatings were completely destroyed after 90 days exposure, but exhibited a relatively good appearance on parkerized sheets even after a corrosion attack of 180 days. (See also *Metals & Alloys*, Vol. 4, May 1933, page MA 138, L8.) EF (13)

The Reflectivity Method for Measuring the Tarnishing of Highly-polished Metals. L. KENWORTHY & J. M. WALDRAM. *Journal Institute of Metals*, Vol. 55, Advance Copy No. 669, June 1934, 10 pages. Apparatus and procedure for measuring both specular and diffuse reflectivity of metals are described. The 2 reflectivities are combined by means of an empirical formula to give a value indicative of the tarnish of a metal. Results of tests on Sn and 2 Sn-rich alloys are given. JLG (13)

The Corrosion of Tin and its Alloys, Part I.—The Tin-rich Tin-antimony-copper Alloys. T. P. HOAR. *Journal Institute of Metals*, Vol. 55, Advance Copy No. 666, May 1934, 14 pages. The corrosion of Sn and several Sn-rich alloys was examined by electrolytic methods and by weight-loss determinations of specimens immersed in dilute HCl, citric acid, and various tap waters. Sb (5%) increased resistance, but additions of Cu to the Sn-Sb alloy decreased resistance. Soft waters produced tarnishing, but hard waters did not. Hard waters tended to produce pitting if there was a heavy chalk deposit. JLG (13)

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APPLICATIONS OF METALS & ALLOYS (14)

Metals and Alloys Used in Naval Engineering (Les Métaux et Alliages Utilisés dans la Construction Navale) Auguste Le Thomas. *Science et Industrie,* Vol. 18, Mar. 1934, pages 69-74. Subjects dealt with can be summarized as follows: (1) Steels used in hull construction: High proportional limit steel is specified more and more for lightening hulls therefore semi-alloy steels containing small amounts of Cr, Cu, Ni, Mo are used, as these steels must remain weldable, their C content must be kept low. Heat treated Cr-Ni steel casting are largely used. (2) Alloy steels are used in marine machines in the following cases (a) when parts must resist fatigue. It is pointed out that failures in these applications are generally due to inclusions or incorrect heat treatment. (b) When strength at high temperature is required, in this case Cr-Ni-Mo steel castings have proved very serviceable. (c) Alloy steels have also solved the problem of turbine blading manufacture. Typical steel used is of the A. T. V. type although Monel metal is also very useful in this connection. (3) Light alloys are used in many applications when pieces are not subjected to vibration stresses and not liable to come in contact with sea water and do not reach in service temperatures over 120°C. (4) Brasses and Cu-Ni (80/20 and preferably 70/30 are largely used in condenser tubes; special cases of corrosion of brasses are explained. (5) Cast Fe treated in electric furnace after tapped from blast-furnace has high quality which makes it very useful in marine engineering; cast Fe castings are in some cases preferable to steel castings. FR (14)

Catenary Curves of Transmission Lines under Consideration of Elasticity and Rigidity (Leitungsseilkurven bei Berücksichtigung der Elastizität und Steifigkeit). F. Niethammer. *Elektrotechnik & Maschinenbau,* Vol. 52, June 10, 1934, pages 266-269. Although influence of elasticity and rigidity of transmission lines can usually be neglected when determining the catenary curves of transmission lines, exact formulas are developed taking these influences into account. Several examples are calculated. Ha (14)

Recent Advances in the Application of Chemistry to Engineering. Harold Hartley. *Minutes of Proceedings of the Institution of Civil Engineers.* Vol. 236, 1932-1933, pages 429-470. In the section devoted to the chemistry of metals, the three main developments in relation of engineering since 1900 are considered. These are the number of new metals and alloys that have become of importance in engineering such as the alloy steels, the light alloys of aluminium and magnesium, and the age-hardening alloys; the improved methods for the purification and melting of metals and alloys; and the advances, which have taken place in metals and alloys due to the Phase Rule, metallographic, and X-ray investigations. JWD (14)

Metals in Building Industry (Die Metalle in der Bauwirtschaft) *Die Metallbörse,* Vol. 24, Mar. 3, 1934, pages 274-275; Mar. 10, 1934, pages 305-311. This series of articles discusses the extensive utilization of ferrous and nonferrous materials in building industry. The various chapters deal with **Significance of Structural Steel in German Industry (Die volkswirtschaftliche Bedeutung des deutschen Werkstoffes Stahls)** Otto von Halem. **Molybdenum-bearing Alloy Steels (Die molybdänhaltigen Edelstähle); Vanadium Steels (Die Vanadinstähle); Utilization of Various Heavy Metals and their Alloys in Building Industry (Die Verwendung verschiedener Schwermetalle und ihrer Legierungen in der Bauwirtschaft); Copper and Copper Alloys in Construction and Interior Decoration (Kupfer und Kupferlegierungen im Hochbau und in der Innenarchitektur); Aluminum and Light Metal Alloys in Building Construction (Aluminium und Leichtmetall-Legierungen im Bauwesen).** EF (14)

Metallurgical Developments and Their Significance. F. C. Lea. *Heat Treating & Forging,* Vol. 20, Feb. 1934, pages 85-88. From the Andrew Laing lecture delivered before the North-East Coast Institution of Engineers and Shipbuilders. See "Metallurgy in Connection with Shipbuilding and Marine Engineering," *Metals & Alloys,* Vol, 5, May 1934, page MA 232. MS (14)

Recent Technical, Economical and Metallurgical Progress (Les Derniers Progrès Métallurgiques, Techniques et Economiques) E. Marcotte. *Arts-et Métiers,* Vol. 87, Mar. 1934, pages 45-67. General survey of French industry. French Fe mines are not rich enough for ore exportation and that interest of France is to sell quality finished products. Following points are then discussed: basic Bessemer steel producted with French ores must be improved in order to compete with open hearth steel. Manufacture of ferro-alloys in the electric furnace has shown great development during recent years. Uses of Al and Al alloys are more and more numerous and important research was carried out on effect of impurities, N absorption, casting of alloys under argon atmosphere etc. . . in order to develop applications of light alloys. Nitrogen hardening is used on Al steels for pieces which must show simultanenously high hardness, corrosion resistance, high hardness at high temperatures. Recent developments in France and elsewhere on the following points are then reviewed: Modification of crystal lattice by high frequency currents. Hardness testing machines with automatic measurement of impression diameters. FR (14)

Laminated Sheet Bronze Graphited Bearings. C. H. Leis. *Product Engineering,* Vol. 5, July 1934, pages 263-265. For bearings to resist high unit loads and impacts, laminated bearing material issued, either bronze-backed, babbitt-lined, or steel-backed, babbitt-lined, or steel-backed, bronze-lined. When the necessity of oiling is to be eliminated a graphite compound is inserted in the inner bearing surface. The applications of the different types in household appliances, agricultural machinery and other special machines are illustrated. Ha (14)

Non-Ferrous (14a)

G. L. CRAIG, SECTION EDITOR

Non-Cracking Lead Alloys. *Chemical Trade Journal & Chemical Engineer,* Vol. 92, Apr. 28, 1933, page 338. Notes on a special Building Research Report entitled, "B.N.F.Ternary Alloys of Lead: Their Use in Buildings," issued by the Department of Scientific and Industrial Research of Great Britain. The properties and specialized uses of ternary alloys containing Pb, Cd, and Sb or Pb, Cd, and Sn are discussed. JN (14a)

Seamless Tantalum Tubes (Nahtlose Tantalrohre). *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, May 6, 1934, page 266; *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, May 27, 1934, page 228. Properties and application of seamless Ta tubes as recently manufactured by Siemens Co., Berlin, are described. Such tubes have been successfully manufactured with inner diameters of from 14-40 mm., with wall thicknesses ranging from .5-2 mm. The length varies according to wall thickness of from 1 to 3 m. Ta is attacked neither by HCl nor by concentrated H_2SO_4, hardly attacked by concentrated HNO_3, ammonia and aqua regia. However it is not stable to attack by HF and concentrated alkaline solutions. GN (14a)

Selenium in the Electrical Industries. Its Value in Metal Rectifiers. *Chemical Trade Journal & Chemical Engineer,* Vol. 91, Sept. 23, 1932, page 270. Allotropic forms of Se include one metallic, one crystalline, and three amorphous modifications. The other forms are converted to the metallic, a steel-grey solid melting above 218° C., by heating above 200° C. Metallic Se and Cu selenide act as rectifiers for converting A.C. to D.C. and are being used on an ever-widening scale for this purpose. JN (14a)

Aluminum Alloys as Piston Materials (Aluminiumlegierungen als Kolbenwerkstoffe) Roland Sterner-Rainer. *Zeitschrift für Metallkunde,* Vol. 26, June 1934, pages 141-142. See *Metals & Alloys,* Vol. 5, May 1934, page MA 233. FNR (14a)

Bearing Metals in Railways of the United States and their Recent Development (Satco-Metal) (Lagermetalle im Eisenbahnwesen der Vereinigten Staaten und ihre neuere Entwicklung (Das Satco-Metal)). Fr. Witte. *Zeitschrift für Metallkunde,* Vol. 26, Mar. 1934, pages 69-70. A discussion of the composition and properties of the high-lead bearing metal Satco-metal. Compositions are given; also bending strength and angle, Brinell hardness, and load-deformation data of Satco-metal in comparison with other bearing metals. Among other advantages Satco-metal shows a higher resistance to deformation at elevated temperatures and is less inclined toward deformation and breakage. RFM (14a)

Piston Material and Design. H. J. Maybrey. *Diesel Engine Users' Association,* S. 120, Feb. 14, 1934, pages 1-20. Piston material should have a low density, high thermal conductivity, low coefficient of linear expansion, a microstructure to give the least cause for wear of the cylinder wall by abrasion, high strength at working temperatures, and a reasonably low cost. Piston alloys are of three main types, the 2.L.8 to 3.L.11 aluminum alloys containing up to 12% Cu, the "Y" alloy, and the binary aluminium-silicon alloys containing over 14% Si. These latter alloys are die-casting alloys with a low coefficient of expansion, 18×10^{-6} maximum as against 22×10^{-6} for the other aluminium alloys. The 35% Si aluminium-silicon alloy has a coefficient of expansion of 13.5×10^{-6}, but is extremely difficult to machine. JWD (14a)

Tendencies in Steam Turbine Construction (Entwicklungsrichtungen des Dampfturbinenbaues) E. A. Kraft. *Die Wärme,* Vol. 57, Mar. 3, 1934, pages 144-148. Critically discusses recent developments in steam turbine design and devotes a special chapter to the construction materials in this special field of engineering. Reliable construction materials are now available for all service conditions. Mo-bearing cast steel containing low additions of Cr and Ni is utilized for housings exposed to extreme temperatures. Up to 470°C. plain cast steel also yielded satisfactory results during long service periods. In the high and low pressure range a 14% Cr—1% Ni steel is employed for turbine blades. In the case of normal service conditions it can be replaced by a 5% Ni steel. The erosion difficulties are attacked from 2 angles, by structural alterations and development of alloys more resistant to wear. The edges of particularly exposed blades are successfully made of special linings such as stellite (U. S. A.) and Mn steel (Germany). The writer however prefers blades entirely made up of high-grade materials instead of wear-resistant linings. EF (14a)

Light Metal Piston Alloys (Leichtmetallkolbenlegierungen). R. T. Edmund. *Die Metallbörse,* Vol. 24, Mar. 24, 1934, page 375; Mar. 31, 1934, pages 406-407. The special requirements to be met by piston materials and 13 most outstanding advantages of light metal pistons are listed. The complete analyses of some 41 most important Al piston alloys are tabulated. The effect of Cu, Zn, Si, Mg, Mn, and Ni in these alloys is discussed and instructions on the melting and casting of light metal alloys for pistons are furnished. EF (14a)

Direct and Indirect Weight Savings on Freight Cars. (Direkte und indirekte Gewichtsersparnis beim Güterwagenmaterial von Eisenbahnen. Allégement direct et indirect aux wagons (marchandises) de chemins de fer). A. M. Hug. *L'Allégement dans les Transports,* Vol. 3, Jan.-Feb. 1934, pages 10-13. In German & French. Calls attention to two American constructions, i.e., to the 70-ton freight cars for the Alcoa Ore Co. and to a 50-ton car for the Pennsylvania Railroad. Although corrosion resistance was the main object in both constructions, considerable savings in weight were realized. Data are presented. The door weight of Swiss freight cars has been more than halved due to adoption of anticorodal. Roof, axle bearing housing, buffers are tentatively made of light metal alloys. The buffer weight for instance has been reduced from 120 kg. (steel) to 50 kg. (Duralumin) and can now be handled by just one laborer. EF (14a)

Reference Tables for Platinum to Platinum-Rhodium Thermo-Couples. Wm. F. Roeser & H. T. Wensel. *Bureau of Standards Journal of Research,* Vol. 10, Feb. 1933, pages 275-287. Reference tables for use with Pt to Pt-10% Rh and Pt to Pt-13% Rh thermocouples have been prepared When these tables are used, the deviation curves obtained for individual couples, have no points of inflection and are, with few exceptions, linear. These tables are based on the International Temperature Scale, so that the indications of a thermocouple whose calibration is obtained by extrapolations of a deviation curve above the Au point will agree in this region with those of an optical pyrometer. WAT (14a)

Strong New Metals for Shipbuilders. W. E. Blewett, Jr. *Metal Progress,* Vol. 25, Apr. 1934, pages 36-42. Review of the properties such as ease of fabrication, physicals, and corrosion resistance of ship-building materials. Properties are shown for three Si-steels, Mn-V steel, 2½% Ni steel and C structural steel. Effects of welding on the properties of these steels are discussed and tabulated. WLC (14a)

Use of Aluminum in Collieries. T. R. Barnard. *Colliery Engineering,* Vol. 10, July 1933, page 233. The most promising use of Al for mining purposes depends upon its lightness. After mentioning the recent application of Duralumin for skips for ore winding in South Africa and cages in Germany, application for other uses is suggested, for instance in place of steel in the construction of props and bank bars, for cases of electric hand- and cap-lamps, of firing batteries, and of portable electric drills for the coal face. Kz (14a)

Ferrous (14b)

M. GENSAMER, SECTION EDITOR

Steel Packages for Chemicals. *Chemical Trade Journal & Chemical Engineer,* Vol. 92, May 19, 1933, plates 402-403. Claims are made for the superiority of steel as a fabricating material for chemical containers. Steel barrels are claimed to be considerably superior to cylindrical drums. JN (14b)

Metals of Wearing Parts of Fuller Crushers (Les Métaux des Pieces d'Usure des Broyeurs Fuller). M. Baudoin. *Chaleur et Industrie,* Vol. 15, Mar. 1934, pages 366-371. Paper read at the 3d Congress of Industrial Heating—Paris, Oct. 10-14, 1933. Comparative tests are made on different parts of the crushers with various C and alloy steels. It is pointed out that Fuller crushers which give good results in America must be adapted and redesigned to give similar satisfactory results with French coals. FR (14b)

Steels in General Shop Practice. Frank J. Allen. *Heat Treating & Forging,* Vol. 20, May 1934, pages 237-242. Abstract in *Steel,* Vol. 94, May 14, 1934, page 46. Paper read before the State College Conference, American Society for Metals, May 4-5, 1934. Discusses selection of machinery steels and tool-steels. Outlines the effects of C and alloying elements in steel and the significance of the various physical properties. Gives data on standard grades of steel to show that a relatively small number of compositions will serve for most applications. MS (14b)

Practical Observations of Some High Carbon High Chromium Tool Steels. W. H. Wills. *American Society for Metals Preprint* No. 29, 1934, 18 pages. The following steels were studied:

No.	C	Mn	Si	Cr	V	Mo
1	2.40	0.35	0.30	11.50	——	——
2	2.10	0.30	0.25	12.00	1.00	——
3	1.55	0.30	0.30	12.00	0.25	0.80

Melting practice, heat treatment, cold drawing, physical properties, and applications are discussed. WLC (14b)

Bumper-Type Steel Plate Road Guard Bolted to Spring Supports. *Steel,* Vol. 95, July 16, 1934, pages 30, 32. Describes guard. MS (14b)

Modern Metals Lend Beauty, Utility to Gas Stations. *Steel,* Vol. 95, July 16, 1934, pages 27, 32. Describes building which embodies a structural steel framework, to which are attached horizontal strips of special extruded Al or stainless steel shapes. These strips have slots top and bottom into which panels of glass or porcelain enameled steel fit. MS (14b)

Goat Barn at Fair Demonstrates New Interlocking Self-Framing System. *Steel,* Vol. 95, July 23, 1934, page 39. Describes insulated, fire-safe steel farm building. Unit, which is used for walls, partitions, roof, and floor, is a channel-shaped panel, 16″ wide and 3″ deep, with flanged sides for interlocking. MS (14b)

Cast Iron and Paving of High-Ways (La Fonte et le Revêtement des Routes). L. J. Gouttier. *Revue de Fonderie Moderne,* Vol. 28, May 25, 1934, pages 145-147. Recent applications of cast iron as paving material and methods of laying are reviewed. Ha (14b)

Cast Iron Blocks Prolong Life of Road Surfaces in Europe. E. W. Davis. *Steel,* Vol. 95, Aug. 6, 1934, pages 31-33, 40. Describes types and gives costs of cast-Fe pavements in use in England, France, and Germany. In England, 2 systems are being tried out. In one, cast-Fe sections are used as surfacing for concrete. In the other, grids, supported directly on a crushed-rock or gravel subbase, replace the usual concrete base, and asphalt mastic is placed directly on this foundation. In the United States, a pavement of the first type will cost about 1/3 more than brick surfacing. Second type will cost a little less than a concrete pavement before asphalt surfacing has been applied. MS (14b)

Have Cast Iron Roads Proved Successful? (Bewähren sich gusseiserne Strassen?) *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, June 24, 1934, pages 260-262. Discusses 3 principally different types of steel and cast Fe road pavements, (1) the steel grate of the German Steel Convention applying that iron as arming material, (2) the Thyssen grate using thin hoop steel and (3) cast Fe grates of hexagonal shape. The results of service tests on an experimental road section equipped with these different materials are discussed. The first mentioned 2 types proved to be inferior to cast Fe grate pavement. The advantages of the latter type are pointed out. A new type of cast Fe pavement, subdivided into scalene triangles, quadrangles and pentagons is described. With this type of grate the load is better distributed on the groundwork. This grate also saves material. GN (14b)

Steel Pit Props and Mine Arches. S. M. Dixon & H. M. Rudspeth. *Iron & Coal Trades Review,* Vol. 128, June 22, 1934, pages 1005-1006. **Estimates Steel Supports in British Coal Mines.** *Steel,* Vol. 95, July 16, 1934, page 35. Steel supports for these purposes are made of 2 types of steel, high-tensile, or rail quality, and low-tensile or mild steel. It may be new material, but rerolling old railway rails is often advantageously practiced. Various shapes in use, test results of steel arches are described and possible developments in future demand discussed. MS+Ha (14b)

The Extended Use of Iron and Steel. T. Stevenson. *Iron & Steel Industry,* Vol. 7, Jan. 1934, pages 144-147. Steel skeleton framework, steel frame windows, steel partitions and floors are becoming more general in the newer buildings. Pressed steel units are practicable in replacing timber in dwelling house construction. Steel office and household furniture are available. Railroad reconstruction utilizing iron and steel is proceeding. CEJ (14b)

Structural Steel in Bridge Construction (Baustähle für den Brückenbau). K. Schönrock. *Montanistische Rundschau,* Vol. 26, Aug. 16, 1934. (Section *Stahlbau-Technik*), pages 1-2. Structural steels of the type St 52 find their principal application in the construction of bridges with long spans, where the dead load must be as low as possible. For any constructions exposed to large and frequently alternating stresses these steels do not, however, offer any special mechanical or economic advantages, as they do not possess any high fatigue limit. The same holds true for small bridges where the dead weight of the bridge is low compared with the actual load. In such cases the older and less expensive type St 37 is still holding its own. BHS (14b)

Wire Ropes: Safety Factor and Bending Stresses. Richard Saxton. *Mechanical World & Engineering Record,* Vol. 95, Apr. 6, 1934, page 327. While a rope must be sufficiently strong for a certain load, the size of pulleys or drums has to be taken into consideration because the bending stress is the stress which contributes principally to fatigue of the steel. Bending of the rope is composed of combined bending and torsion of the wires. Resistance to bending of different types of wire ropes is discussed. Increased resistance to bending decreases working life. Kz (14b)

Wire Ropes for Building and Highway Contractors. Henry M. Hall. *Canadian Engineer,* Vol. 66, Mar. 20, 1934, pages 3-5. The various types of wire ropes are illustrated and the types most likely to give the best service on the various kinds of equipment indicated. VVK (14b)

Cements for Foundry Purposes (Kitte für die Giesserei). *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, June 24, 1934, pages 267-268. Discusses composition and application of various types of cements used for densifying defective castings. GN (14b)

Nickel Alloys for Tools (Les Alliages de Nickel dans l'Outillage). *Usine,* Vol. 43, May 24, 1934, page 27. Rapid cutting machines used Ni steels with 0.15 to 0.45% C, 1 to 5% Ni or 0.25 to 0.40% C, 2.5 to 3% Ni 0.6 to 1% Cr. A recent alloy steel for shears, chisels, etc., is 0.38-0.42 C, 3-3.5% Ni, 0.6% Mn. Castings for machine tools with pearlitic structure are of 2.7-3.1% C, 1.2-2% Si, 0.4-0.6% Mn 0.3% P and 1-2% Ni; they have great hardness and are principally used for beds, slides and cylinders of hydraulic presses. Ha (14b)

Steels in Marine Engineering Service. T. H. Burnham. *Institute of Marine Engineers,* Vol. 45, Feb. 1934, pages 1-40. See *Metals & Alloys,* Vol. 5, June 1934, page MA 299. Kz (14b)

Large Uses of Steel in Small Ways. No. 265. Domestic Stokers. *Steel,* Vol. 95, July 16, 1934, page 38. About 9500 units were produced in 1933 indicating an annual consumption in the industry of 2500-3000 tons of various steel products, in addition to a small tonnage of iron and steel castings. MS (14b)

Emphasizing "Stainless" Instead of Brand Names Will Aid Sales. *Steel,* Vol. 95, Aug. 6, 1934, pages 29-30. Points out that manufacturers of stainless steel have depended too much on brand names but have failed to identify their product as stainless. Suggests cooperative action for promoting uses and sales of this steel. MS (14b)

Large Uses of Steel in Small Ways. No. 266. Rolling Doors. *Steel,* Vol. 95, July 30, 1934, page 31. Outlines constructional features. About 5000 tons of steel are consumed annually in manufacture of this equipment. About 15% of the total weight of an installation is cast-Fe. MS (14b)

Light-Weight Elevated-Subway Car Constructed of Stainless Steel. *Steel,* Vol. 95, July 16, 1934, pages 23-26. Describes 5-section car built for the New York Rapid Transit Corp. Structure and sheathing are made of shot-welded 18-8 steel. Cromansil steel is used in the trucks. Crumpled Al foil is used for insulation. Car is similar in structure to the Burlington Zephyr. MS (14b)

Cold-Drawn Steel for Special Sections. *Product Engineering,* Vol. 5, July 1934, pages 257-260. The advantages in simplified design, longer wear, closer tolerances and improved appearance as well as in reduced machining costs, by cutting parts from specially drawn steel sections are illustrated by many examples. Ha (14b)

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Application of Steel Castings in Mining Equipment. William M. Sheehan. *Mining & Metallurgy,* Vol. 14, June 1933, pages 257-259. Abstract of a paper delivered before the Coal Division of the American Institute of Mining Engineers in New York. Outstanding developments in the construction of railroad equipment has been the widespread adoption of large one-piece steel castings for the framework of locomotives, passenger and freight cars. Some of the advantages and applications of this type of construction are outlined, with particular attention to the needs of the mining industry. VSP (14b)

High-Chromium Iron Alloys for Castings. W. F. Furman. *Metals & Alloys,* Vol. 4, Oct. 1933, pages 147-150; Nov. 1933, pages 167-169. The use of high chromium castings is much older than would be suggested by some recent accounts of their development abroad. In this country castings containing from 16% Cr to 30% and C 0.10 to 2.75% have been commercially produced for over 10 years. Properties of alloys discussed. WLC (14b)

Chromium Steel for Brewery Equipment. H. D. Edwards. *Refrigerating Engineering,* Vol. 26, Oct. 1933, pages 192-194, 211. General discussion of 18-8 Cr-Ni steel and its properties. 18-8 is widely used in the brewing industry having no effect on the quality of brew produced and not being affected by it. VVK (14b)

Drilling with a Detachable Bit. A. H. Hubbell. *South African Mining & Engineering Journal,* Vol. 43, pt. II, Jan. 14, 1933, pages 343-344; Vol. 44, pt. I, Aug. 12, 1933, pages 447-448. Advantages of detachable bits, steel consumption, etc. AHE (14b)

More Steel Is Required for Electric Display Signs. *Steel,* Vol. 94, Apr. 30, 1934, pages 27-28. Electric signs offer an expanding market for steel products. A spectacular sign completed recently required 330 tons of structural steel and 33½ tons of enameling sheets. MS (14b)

Large Uses of Steel in Small Ways. No. 258-261. *Steel,* Vol. 94, Apr. 9, 1934, page 34; Apr. 23, 1934, page 36; May 7, 1934, page 46; May 21, 1934, page 53. Deals with hand trucks; mopping tanks; ventilating fans; and magnetic separators. MS (14b)

Large Uses of Steel in Small Ways. No. 262. Lift Trucks. *Steel,* Vol. 94, June 4, 1934, page 46. About 1000 tons of steel, chiefly bars and flats, are consumed annually in the manufacture of lift trucks. More than 3000 tons of steel are consumed annually in the fabrication of platforms used with the trucks. MS (14b)

The Rail of the Future. *Railway Engineer,* Vol. 55, Mar. 1934, pages 67-68. The phenomenal wearing capacity of some of the rails rolled in the earliest days of steel making is ascribed to work-hardening. The result of the high C tendency (.8% C) in the U.S.A. has been to produce a steel whose tendency to disintegrate under traffic has decreased rather than improved its wearing capacity, and the liability to fissure during the cooling of the rails has added the danger of brittleness. The addition of Cr is considered to be most promising, great care in rolling and control of cooling presumed. Mn steels (12-14% Mn) have furnished the toughest steels on record but they cost 4-6 times more than ordinary C steels. The utilization of 1.25-1.5% Mn steels is predicted and the modern developments which lie in the direction of heat treatment are discussed with the view of increasing wear resistance without brittleness. WH (14b)

How Alloy Steels Eliminate Dead Weight. *Oxy-Acetylene Tips,* Vol. 12, July 1933, page 154; *Blast Furnace & Steel Plant,* Vol. 21, Dec. 1933, page 639. The better mechanical properties of alloy steels permit reducing the weight of material to such extent that in spite of the higher price savings can be made; a few examples of shafts, boiler plates, etc., are given as illustrations. Ha (14b)

Steel Lining for Mine Roads. *Iron & Coal Trades Review,* Vol. 128, May 18, 1934, page 797. Comparative data for brickwork, concrete and steel lining of mine roads, saving in weight, and methods employed in Germany. Ha (14b)

Joints for Cast-Iron Mains and Piping. Notes on a Century of Progress. A Review of Some Special Designs. *Gas Engineer,* Vol. 59, Mar. 1934, pages 123-126; Apr. 1934, pages 199-203; May 1934, pages 251-255. Illustrates 64 different kinds of cast Fe pipe joints, and discusses the subject under the following headings: more permanence, rubber-packed joints, merits of rubber gaskets, ball and socket, typical classifications, flange joints, modified flanges, turned and bored joints, bell and spigot, rubber rings, protecting rubber, Zimmermann joint, "self-healing" joints, modified bell and spigot, malleable couplings, Acme joint, features of "true" joint, joint for DeLavaud pipe, bronze welding, bell joint clamps, latest clamp. WH (14b)

Materials for High Temperature Valves and Fittings. *Commonwealth Engineer,* Vol. 21, Jan. 1, 1934, page 166. Reviews the properties of ferrous and nonferrous materials at elevated temperatures and points out the favorable change of physicals due to addition of Mo to steel according to Kanter and Maack. For bolting steel a low initial creep is essential. The superiority of Cr-Mo steel (SAE 4140) to a Ni-Cr steel (SAE 3140) at high temperatures is claimed. The tensile properties at all temperatures as well as corrosion resistance and temper brittleness of 12-14% Cr steel and 18/8 Cr-Ni steel are improved by additions of Mo or W. For valve seatings, stainless Fe is perfectly satisfactory for oil and vapor control, but quite impractical for dry steam. Non-ferrous alloys as brass, bronze, copper, nickel, and Cu-Ni rapidly corrode in hot crude oils. Nitriding overcomes difficulties involved in high pressure steam, while carburizing induces rapid rusting. Alloys of the stellite type are particularly satisfactory in regard to wear. WH (14b)

Pipe Line Construction (Umwälzung im Rohrleitungsbau). Alfred Schmidt. *Die Wärme,* Vol. 56, Dec. 16, 1933, pages 819-821. Cast Fe boiler parts have been abandoned in favor of cast steel ones. S + P must be below 0.05% 45 kg./mm.^{2} tensile strength and 24% elongation assured. Electro cast steel is preferred although Bessemer and open hearth steel is not at all inferior, reliable manufacturing methods presumed. Plain mild steel (34-45 kg./mm.^{2}) is alloyed with Mn (45-55 kg./mm.^{2}) and for extreme temperatures Mo, Cu, Al, Si or Ni are added. Recent tendencies in working of tube materials (hot and cold working), heat treatment, testing and joining methods are discussed as well as recent contributions of mechanical engineering in the field of pipe line construction. EF (14b)

Rail Failures in Siberian Winters. B. M. Suslov. *Metal Progress,* Vol. 25, Dec. 1933, pages 45-47. Excessive rail failures on the Siberian railway are experienced in the winter months when a temperature approaching —43° to —53° F. is experienced. Rail steel heat treated (composition not given) to a sorbitic structure while much tougher at temperatures down to slightly below 0° F. drop off very rapidly in their Charpy values at —40° F. Graphs show these variations in Charpy values with temperature. A steel containing Cu 0.85% and Cr 0.51% appears to retain greater toughness at low temperatures. For Siberian rail service suitable alloy and heat treatment appears necessary to eliminate excessive failures. WLC (14b)

Scale Springs. *Product Engineering,* Vol. 5, June 1934, page 207. Materials used in springs, self-compensating springs and recent metallurgical developments are described. Maximum error in modern spring systems does not exceed 0.08%. This development was made by John Chatillon & Sons. Ha (14b)

Forming, Welding and Finishing Sheets in Manufacture of Commercial Shelving. *Steel,* Vol. 94, May 21, 1934, pages 26-27. Describes production methods of Lyon Metal Products, Inc., Aurora, Ill. MS (14b)

Methods and Materials Play Important Role in New Train. *Steel,* Vol. 94, May 7, 1934, pages 30, 32, 34. Deals with the "Zephyr," the new streamlined train. See also *Metals & Alloys,* Vol. 5, May 1934, page 244. MS (14b)

GENERAL (15)

RICHARD RIMBACH, SECTION EDITOR

Science and Technical Progress (Wissenschaft und technischer Fortschritt). I, W. Heisenberg, II, P. Goerens. *Stahl und Eisen,* Vol. 54, July 19, 1934, pages 749-760 General. Heisenberg discussed atomic structure and the theory of ferromagnetism; Goerens, the development of transformer steel, permanent magnet steel, tungsten carbide tools, effect of inclusions, grain boundary precipitation in 18-8 stainless. SE (15)

Development of "Y" Lacquer. Robert W. Belfit. *Metals & Alloys,* Vol. 5, July 1934, pages 147-148. Describes the development of lacquers giving metal articles greater protection against a greater variety of conditions. WLC (15)

Protection of Workers Exposed to Chromium and Its Compounds. Industrial Health Section, Metropolitan Life Insurance Co., New York, 1933. Paper, 6x9 inches, 20 pages. Free. Thorough treatment but written for non-technical readers. Divisions: Toxicity; Uses; Modes of Contact; Effects on Workers; Preventive Measures (Plant Hygiene, Personal Hygiene, Medical Supervision, Treatment); and The Determination of Chromates in the Working Environment. Declares that harmful effects "can be wholly eliminated or reduced to a minimum. . . . Responsibility equally divided between management and workers." MFB (15)

The Chemical Formulary. H. Bennett, Editor-in-Chief. The Chemical Formulary Co., Brooklyn, 1933-34. Cloth, 5½ x 8½ inches, 595 pages. Price $6.00.

This is alleged to be a condensed collection of valuable, timely, practical formulae for making thousands of products for one's own use or for sale. Over 40 industrial chemists, professors and technicians, have, it is stated, cooperated to make this "not just another book of recipes."

No metallurgist is listed in this cooperative brain trust, but some alloy composition, plating formulae, etc., are included. Most of these are starred to indicate that they are patented. Some of the formulae are weird and wonderful. To harden steel, you heat linseed oil to the boiling point, add ⅛ lb. resin per gal., immerse the iron or steel until it attains the same temperature, remove, cover with powdered resin and quench in cold coal-oil. The preface warns that two individuals using the same materials in the same formula may get different results, also that it is seldom that any formula will give exactly the results which one requires.

Another recipe for a thermocouple is for 3 to 15% rhenium, balance platinum, but it neglects to state, "first catch your rhenium." The average user of such a book would probably expect to get it at the drug store.

We cannot speak highly of the metallurgical recipes as a whole. Those for removal of tattoo marks (by incidentally removing the skin) straightening hair, tanning python skins, making up embalming fluid, exterminating bed bugs, making a honeysuckle perfume base (19 constituents) and Parfait Amour Liqueur all sound more interesting to us.

The book is to be recommended for perusal on a long winter's evening, but for purposes other than the extraction of metallurgical information. Among the list of "references consulted" is Metals & Alloys, but so far as we can see no information ever published in Metals & Alloys got into the formulary. Inclusion in the list seems a doubtful compliment. H. W. Gillett (15)—B—

Application of Statistical Methods in Foundry Operation (Die Anwendung statistischer Methoden im Giessereibetrieb.) F. Brinckmann & A. Nehmitz. *Die Giesserei,* Vol. 21, Apr. 27, 1934, pages 173-178. The use of frequency or statistical curves for detection and determining causes of defects, for supervision of raw materials, and to use such statistics to find relations in certain occurrences in the operation, for instance the amount of rejections in relation to composition, is explained and illustrated by curves. Ha (15)

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Steel. S. S. Podoprigora. Gosudarstvennoe Naouchno-Technicheskoje Izdatelstvo, Moscow, 1933. Cloth, 6 x 9 inches, 675 pages. Price 11.25 roubles. This is a handbook, but a peculiar one, rather an album of diagrams and tables with a sprinkling of text. Presenting facts in pictures is the basis of it, an entirely new idea in metallurgy but a well tried one in elementary education. An astonishing amount of material collected from the literature of the world is offered here as diagrams, pictures, micrographs and tables. Hardly a point is omitted which might be of interest to any one associated with steel, its properties, testing specifications and the theoretical aspects underlying it. The literature was gone over with a fine comb, and its substance is condensed here in 1039 diagrams and micrographs, 173 tables and a few pages of writing. The work does not preach, it gives figures and facts as found by different investigators. To every statement is added the name of its author and a reference where the original work can be found. A procession of eminent metallurgists of the past quarter of the century passes before the reader. The book is a true encyclopedia of everything which is connected with the properties of steel.

Any criticism directed towards the data presented would be entirely out of place. The compiler is not responsible for them, his duty is to determine the interest of a point, to select among the authorities and to decide how fully any given subject should be presented. Many were invited, but only a few were chosen to supply the requirements of this work. Most of the names mentioned belong to men who have carned for themselves an enviable reputation both in Europe and in the United States, though a few are strangers to the Western world. The book can claim as high a technical standing as any one on the market.

Dealing with so much material always leaves some points open to discussion. The segregation in the steel ingots would be clearer illustrated if the data of H. M. Howe were replaced with later and more accurate. The Erichsen testing method is found in the chapter on hardness, and its thickness correction chart is not given. Only the Rockwell hardness tester is illustrated and fully described, while other machines are not, though the results obtained and conversion tables connected with them are abundant. Glycerine base etching reagents for stainless steel are not included in the list of etching solutions though they are quite popular. Several Fe-Si equilibrium diagrams are available which are more up to date than Murakami's used in the book. Magnetic properties of silicon sheets certainly command a sufficient interest to warrant their listing. There does not seem to be any need for presenting both the properties of heat treated steels as adopted by SAE and those found by D. K. Bullen. In the chapter on carburizing no mention is made of abnormality and testing methods employed for determining the carburizing quality of steel. Sintered carbide metals are exemplified in widia alone, and even then without giving any information on its nature and composition. Properties of metals described only by their trade names are given. This is particularly pronounced in case of stainless and heat resistant steels. One cannot find any comparison between the properties of plain austenitic stainless steels and those protected from intercrystalline corrosion by addition of carbide forming elements. Methods for determination of intercrystalline corrosion are absent.

All these, however, are but minor defects. The first step is the hardest and the following editions will improve undoubtedly the quality of the present. One has no hesitation in predicting that many later printings will be required, the possibility of acquiring a complete and reliable metallurgical library for an equivalent of about twenty five cents cannot fail to speed its sales. Cost reduction associated with larger volume would warrant a better paper, at least for the photomicrographs some of which are barely decipherable, and better proof reading. On the whole it is a very good and useful work, but only the future can tell whether or not the method of presentation adopted in it would meet with the public approval. E. L. Reed. (15) -B-

Steel Developments of the Past year. L. Sanderson. *Steam Engineer,* Vol. 3, Apr. 1934, pages 300-301. Developments include centrifugal casting of alloy steels; jointly fabricating metals and plastic substances; 2 new steels for pressure vessels (Mo 0.40, Cr 0.7, Ni 2.5, Mn 0.5, Si 0.15, and C 0.30%; Mo 0.5, Cr 1.1, Ni 3.5, Mn 0.5, Si 0.2, and C 0.30%; vessels stand 35 tons/sq. in.); malleable stainless steel, stainless steel wire; coating steel with Pb before mfg. of steel tubes by cold drawing to reduce amt. of annealing required; heat-resisting steels in bars, sheets, billets, etc. (lower C); extension of knowledge of effect of nitriding; effect of V in steels; improvement of Ni-Cr-Mo steel; fabrication of shank and cutting edge of drills of different materials; resistance to corrosion and wear of Ni-Cr-austenitic steels increased with Si and Cu; heat treating steel in Cl to increase corrosion resistance; graded or interrupted hardening to prevent cracks and soft centers; introduction of rare metals into steel, etc. AHE (15)

List of Mines, Metallurgical Works and Quarries. *Ontario Department of Mines, 42nd Annual Report,* Vol. 42, Part 1, 1933, pages 50-60. Tabular. AHE (15)

The Use of Blast-furnace Slags (Die Verwendung der Hochofenschlacke). A. Guttmann. Verlag Stahleisen, Düsseldorf, 1934. Cloth, 6 x 8¼ inches, 462 pages, 2nd edition. Price 16 RM.

Composition, methods of granulation and crushing, and the uses of slag as cast paving brick, as raw material for cement, as an aggregate for concrete roads and structures, as road-paving material such as filler in asphalt, for railroad ballast, in slag-lime brick and in porous brick, are described.

A little attention is paid to slag wool for sound and heat insulation, for use as a substitute for lime on acid soils, and to other minor uses, among which the possibility of using it as part of a glass-making charge is mentioned.

American practise is occasionally considered, though the bulk of the account deals with German methods.

Many illustrations are given of pavements, buildings and structures made from slag products. Methods of testing for its suitability for different purposes are included. The book is well printed, bound, and indexed. H. W. Gillett (15)—B—

Economic (15a)

Designing and Casting (Konstruieren und Giessen). Karl Sipp. *Die Giesserei,* Vol. 21, May 11, 1934, pages 191-195. Lack of coöperation between designer and foundry, particularly in plants which have no foundry of their own, may lead to serious defects in product as also to more expensive operations. Examples illustrate most important points, i.e., new material instead of scrap in the foundry, consideration in the design of shape and machinability, handling of the casting, etc. Ha (15a)

Transcaucasian Copper Industry. A. Duk. *Tzvetnuie Metallui,* No. 1, Jan. 1934, pages 29-39. A description of the deposits, mining operations and reconstruction of smelters at Allaverdui and Zangezur districts, and a discussion of the factors responsible for the failure to bring the production up to the plan. BND (15a)

First Soviet Nickel. D. M. Chzhikov. *Tzvetnuie Metallui,* No. 6, Aug. 1933, pages 3-16. A description of the first Soviet nickel plant, at Ufaley, Ural. The ore supply comes from the oxidized Ni ore deposits in the vicinity of the works with the average Ni content of 2%. The proved ore contains 16,000 tons of Ni. It is intended to smelt the ore into the Fe-Ni matte, and separate and refine the Ni. The approved metallurgical processes, furnaces, and the ore mining conditions are described. The plant was to be put in operation during the winter 1933. BND (15a)

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Tin in France (L'Etain en France). V. Charrin. *La Revue Industrielle,* Vol. 64, Apr. 1934, pages 218-220. Location of ore sources is given. French mines do not operate actually but in 1927, when tin was very expensive, 500 tons of ores were treated in France. FR (15a)

Fuel and Iron and Steel Trades of Belgium. *Iron & Coal Trades Review,* Vol. 128, June 15, 1934, page 973. A report on the economic conditions in 1933 of Belgium and Luxemburg to the Department of Overseas Trade is given and figures for sales and production allocated by the International Hoop Iron Cartel reproduced. Ha (15a)

Historical (15b)

Metals in the Service of Human Life and Industry. H. Carpenter. First Annual Research & Development lecture, May 16, 1933. 33 pages. Published by the British Science Guild, price 1 s. Traces development of metallurgy from prehistoric times through modern developments. Interesting survey, intelligible to the non-technical reader. H. W. Gillett (15b)—B—

Purity of Metals 2000 Years Ago (Über die Reinheit von Metallen vor 2000 Jahren). August Ebeling. *Zeitschrift für Metallkunde,* Vol. 26, May 1934, pages 116-118. A discussion of the purity of several varieties of ancient lead and copper. RFM (15b)

An Historical Structure Almost Entirely of Cast Iron (Ein historisches Maschinenbauwerk fast ganz aus Gusseisen). R. Kuehnel. *Die Giesserei,* Vol. 21, May 11, 1934, pages 200-202. Describes a pump for the saline waters of the health resort Kissingen, which is made entirely of cast iron and still in service since 1848; it operates in open air without protection. Ha (15b)

Rolls and Rolling Mills. Harold E. Cookson. *Iron & Steel Industry,* Vol. 7, Nov. 1933, pages 53-55. A history of rolls and rolling mills in England. First mill introduced probably in 1590 at Dartford. CEJ (15b)

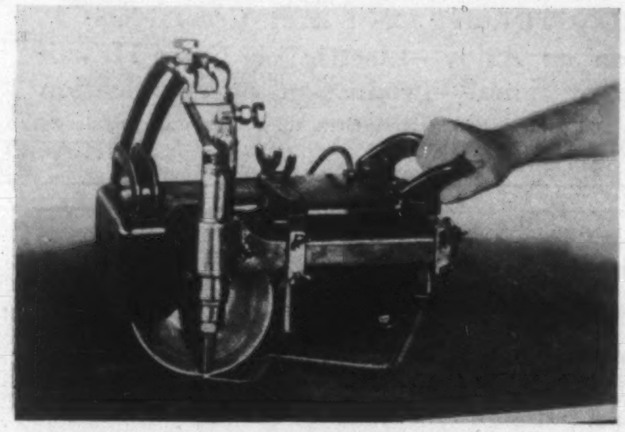
Solingen Steel Ware (Solinger Stahlwaren). *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, May 20, 1934, pages 286-287. After briefly discussing history of Solingen steel ware industry, modern cutlery making machinery as used in the plants of Solingen is described. GN (15b)

History of Arc-Welding. *Sheet Metal Worker,* Vol. 25, June 1934, page 221. A few historical notes on equipment and use of welding in place of riveting. Ha (15b)

NEW EQUIPMENT AND MATERIALS

New Airco Tractograph

The Airco-DB Tractograph, latest addition to the Airco-DB line of oxyacetylene cutting machines, manufactured by the Air Reduction Sales Co., New York, is said to provide a simple means for accurately cutting steel plates and slabs into shapes having straight, circular or irregular outlines and extending over practically unlimited areas. It is intended for the cutting of plates and slabs up to 2" in thickness. It is a small, compact, motor-propelled unit which can be quickly adjusted to travel at any speed from 2½" to 36"/min. As it travels it is guided by hand along the desired contour laid out and scribed directly on the plate or slab. The Tractograph will cut bevelled as well as perpendicular edges. With the radius rod in place it will automatically cut arcs or complete circles. Circles or arcs of smaller radius than the minimum possible with the radius rod, can be cut with manual guidance. Also, it is capable of traveling up an incline of approximately 10° on ordinary hot rolled steel plate without slipping. Measuring only 7¼" x 8" x 16", and weighing but 48 lbs., the Tractograph can be easily carried about and used wherever 110 volts, a.c. or d.c. current is available.



New High Tensile Steels

The United States Steel Corporation announces the development of three high tensile steels for light weight construction. The names used to designate these steels are Cor-ten, Man-ten and Sil-ten and are partially indicative of either the individual characteristic or the predominating element. Cor-ten is a low chromium copper silicon steel with an atmospheric resistance estimated at from 4 to 6 times that of regular carbon grades of steel. Man-ten is a lower-priced medium manganese steel for applications where the corrosion resistance of Cor-ten is not required. Sil-ten is a strong structural steel of still lower price, for applications where neither the atmospheric corrosion resistance, nor the superior physical properties of the two former steels are essential.

Composition and Properties	Regular Open Hearth	USS Cor-ten	USS Man-ten	USS Sil-ten
Carbon .....%*	0.10	0.10	0.35	0.40
Manganese ..%	0.50	0.10 to 0.30	1.25 to 1.70	0.70 to 0.90
Phosphorus ..%	0.04	0.10 to 0.20	0.04	0.04
Sulphur .....%	0.05	0.05	0.05	0.05
Silicon ......%	0.10	0.50 to 1.00	0.15 Minn.	0.20 to 0.30
Copper ......%	0.20†	0.30 to 0.50	0.20†	—
Chromium ..%	—	0.50 to 1.50	—	—
Corrosion Resistance—Atmospheric, Comparative	1 (or 2 to 3† with copper)	4 to 6	1 (or 2 to 3† with copper)	1 (or 2 to 3† with copper)
Yield Point, lbs./in.² ...	25 to 35,000	50 to 60,000	55 to 65,000	45,000
Tensile Strength, lbs./in.² ...	35 to 50,000	65 to 75,000	80 to 90,000	80 to 95,000
Elongation, % in 2 in...	34 to 25	27 to 22	25 to 20	23 to 18
Impact Izod, ft.-lbs.	30	60	40	—
Endurance Limit, lbs./in.² ...	25,000	45,000	40,000	—
Density, lbs./in.³ ...	0.283	0.283	0.283	—
Weldability	Good	Good	Good	Good

(Regular Open Hearth Steel included here for comparison only.)

*Maximum—if no range or other limit indicated.

†Minimum—if copper specified.

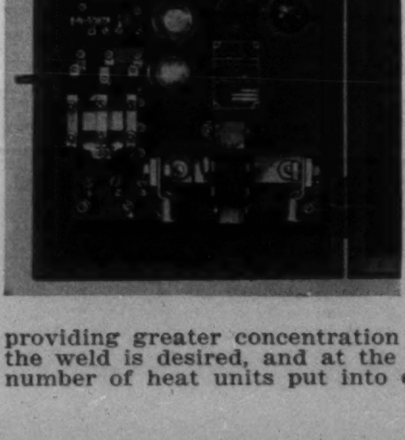
Modulus of elasticity—28 to 30,000,000.
Impact and endurance values are only approximate and have not been determined for sheets.
Reduction in area is not considered for sheets.

A Diamond Grinding Wheel

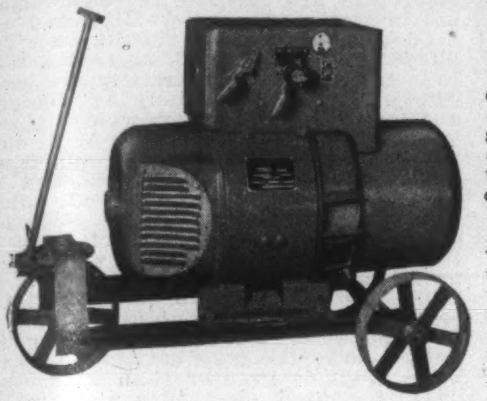
The Carborundum Company, Niagara Falls, N. Y., announced and demonstrated another contribution to industry at the National Metal Congress. It is the Diamond Wheel—a grinding wheel made from genuine South African diamonds, which judging from the results of exhaustive tests is destined to revolutionize the shaping and conditioning of the hard cemented carbides, trade-named Carboloy, Firthite, Vascoloy-Ramet, Carmet, Widia, etc., so extensively used in turning and boring tools. Present tests also indicate that the new wheel will find wide and varied use in the grinding of other materials and metals difficult to grind quickly and economically. It is interesting to note, by way of comparison, that the manufactured abrasive Carborundum Brand Silicon Carbide is rated in hardness at 9.17 on the Moh's Scale. The cemented carbides are rated at from 9.12 to 9.14 with the diamond at 10, showing very little difference in hardness between the hardest of manufactured abrasives and the cemented carbides, but still enough difference, however, to enable specially developed and bonded Green Grit Carborundum Brand Wheels to do a most creditable job of grinding on this material. Progress in the abrasive art, the demand for greater speed and production, the perfection of finishes and edges called for a further improved wheel, as a companion wheel for the "Green Grit" wheel, for the grinding of the hard cemented carbides and comparable materials, hence the advent of the new Diamond Wheel. The diamonds used in the manufacture of the new wheel are not of the so called black or carbon type. They are yellows, white and grays of the gem diamond variety, but of course are sufficiently off-color and in such small sizes or weights as to be not desirable as gems. By a special process the diamonds are crushed and the diamond grains or grits most accurately graded through a series of standardized screens. One of the problems in the perfection of this new wheel was the development of a bond that would be at once tenacious, tough, durable—one that would permit the permanent holding of the tiny diamonds securely and give them full opportunity to cut. Such a bond was developed in The Carborundum Research Laboratories and with marked success. It is obvious that regular or solid wheels with diamonds as the abrasive would be prohibitive in cost, so a composition form or backing was devised to which is applied a coating of the diamonds and the bond. This layer about one eighth of an inch thick is applied to the side of the wheel form for side grinding and to the periphery of the form for cylindrical and other types of grinding. The wheels are then baked by a specially developed process. Throughout the entire process these wheels must be made to micrometer exactness, and they are balanced to within a fraction of a gram. They are so hard that it is impossible to turn or dress them to size. These new wheels are made in three grits, the comparatively coarse, 90 grit; the fine, 220 grit and the extra fine, 400 grit. With this range of grits it is possible to do the comparatively rough grinding or stock removing with the coarse wheel, to produce an edge superior to a lapped edge with the fine wheel, and to create an exceedingly keen edge and a mirror surface finish, where such finish is required, with the extra fine wheel.

Improved Automatic Weld Timer

For use with resistance welding machines, The Electric Controller & Mfg. Company, Cleveland, Ohio, announce the Folio 2 EC&M automatic weld timer. This device takes into consideration the many variables entering into the welding circuit and timing the weld with respect to the current flow. The fast operation of this timer not only makes it possible to produce many more welds per minute for a given material, but also greatly increases the number of different kinds and also the variety of thicknesses of metals which now may be satisfactorily welded under the control of this new timer. In practice, for example, it has been demonstrated that when welding certain alloys and metals of high thermal conductivity, a high current with extremely short time must be used. Under these conditions the increased speed of operation will make it possible to use a higher heat tap on the welding machine, thus providing greater concentration of the heat at the point where the weld is desired, and at the same time closer control of the number of heat units put into each weld, can be secured.



Improved Arc Welding Set



A line of improved, portable, single-operator arc-welding sets which retain the proved characteristics of previous models and incorporate recently developed refinements, is now offered by the General Electric Company, Schenectady, N. Y. Self-stabilization is the outstanding feature of the new arc welders—an advantage which is claimed to provide excellent performance throughout the entire welding range, using any type of electrodes, bare, lightly fluxed, or heavily coated. These welders belong to what is designated as the WD-30 line. Each welder is a self-contained unit, having no external reactor, resistor, or separate exciter. It is largely due to the self-excited design of these machines that the inclusion of sufficient self-stabilization to provide steady welding characteristics under all conditions is possible. Separate controls are provided for adjustment of welding current and welding voltage. These controls are located on a dead-front panel on top of the machine and at the most convenient height above the floor. On this panel are also located a switch handle for reversing polarity and an instrument with selector switch for indicating welding current and welding voltage. All controls are clearly labelled to facilitate rapid and accurate adjustment. Commutation is excellent at all current values, and operating efficiency is high because of the lack of power-consuming accessories such as external reactors, resistors, and separate exciters. All working parts of the machine are thoroughly protected against damage from water or other foreign materials by completely drip-proof construction. The entire welding set is low-hung on a three-wheeled truck which provides unusual portability and mechanical stability, without sacrificing road clearance. The set may safely be tipped as much as 22° from the vertical.

New Furnace Treats Tools With Radio Frequency

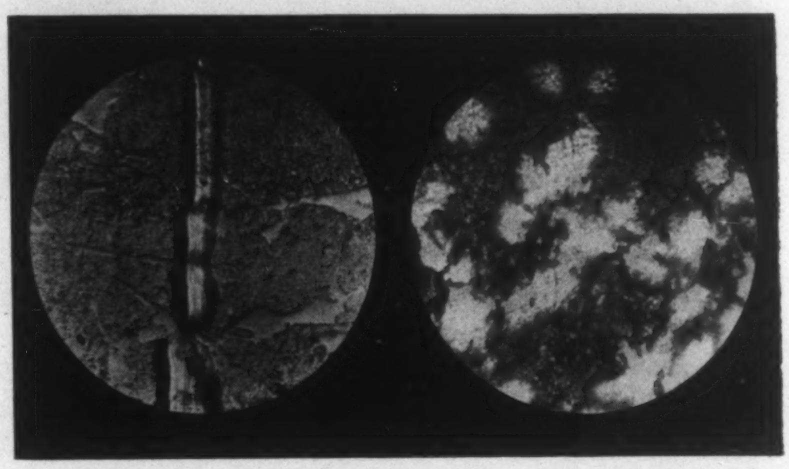
Experiments are being made by the Westinghouse Company on the use of radio frequency in the treating of small tools. Radio frequency current from an oscillator is made to pass through a coil about the size of an ordinary coffee cup. The tools to be treated are placed inside of this coil and their opposition to the flow of the radio frequency current through the coil causes them to become heated to the temperature required for treatment. One small model weighing not over 75 lbs. was manufactured at the Radio Division of the Westinghouse Company, Chicopee Falls, Mass., and has been successfully used in the treatment of lathe tools, drills, etc. The model as it was arranged was very convenient especially for small quantity production of small tools. Where the ordinary gas furnaces are not available, or where regular furnaces are too costly to start up for only a few tools, this radio frequency furnace is extremely useful. The coil is connected to the oscillator through a long flexible cable, and by having the tools to be treated arranged in a rack the operator can easily and quickly bring the coil up to each successive piece without removing it from the rack. Tubes used in the oscillator are of the same type as those used in ordinary broadcasting transmitters. The frequency of the induction furnace is 375 Kcs., a frequency which approaches the lower end of the radio broadcast band. The output of the oscillator delivered to the coil for heat treating is approximately 100 watts. Two tubes are used in a circuit which provides self-rectification of the 60 cycle input power and the total input is not in excess of 400 watts, therefore requiring less operating power than an ordinary flatiron.

New Aluminum Process Found

A process for the manufacture of aluminum, which it is claimed will make America independent of obtaining that product from foreign countries and will tremendously increase its use in the automobile and other industries, was announced by Charles B. Bohn, President of the Bohn Aluminum & Brass Corporation, Detroit. Mr. Bohn stated that the process, which involves the use of alunite ore, results in a purer product than present manufacturing conditions allow. A $50,000 plant will be constructed immediately, he added, to perfect production operation.

Alumiliting Process for Aluminum Alloys

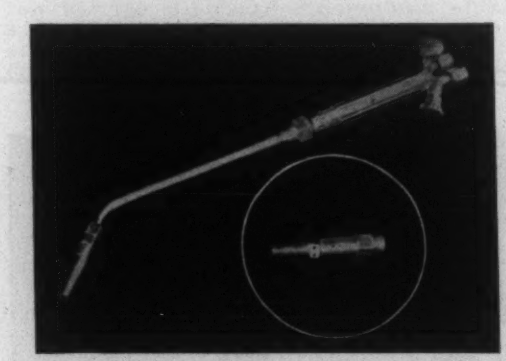
The latest step in the evolution of the aluminum alloy piston is Alumiliting—a process developed by the engineers of the Aluminum Company of America, which forms a hard, smooth aluminum oxide surface as an integral part of the piston. This surface is said to have fine bearing qualities and materially increases the resistance of the piston to scuffing. The life of a piston thus treated is substantially lengthened while cylinder wall wear is reduced. The harder surface is made by electrolytically treating the piston by the Alumilite process. The Lo-Ex aluminum alloy pistons are electrolytically treated in large tanks; the equipment resembles that used for electroplating. If desired, the operation can be made fully automatic and continuous. Machining and grinding are done before treatment and the thickness of the Alumilite finish can be controlled uniformly and within close limits. The oxide surface is made out of the metal and is not a layer of material deposited on the surface. This accounts for the tenacity with which it adheres to the piston surface and explains why there is little change in diameter during the treating process. The Alumilite finish has the hardness and smoothness of a fine bearing surface. In addition, it contains innumerable invisible surface cavities which absorb oil and the importance of this, when the engine is first started, is recognized. The hardness of the Alumilited surface is of material benefit in reducing ring-groove wear and in maintaining piston pin bore diameters within their original limits. Unusual protection against scuffing is obtained.



(a) (b)

Microscratch in Lo-Ex Alloy Piston: (a) Untreated surface; (b) Alumilited surface. The scratch in each case was made with a cubical diamond point loaded with 3 grams.

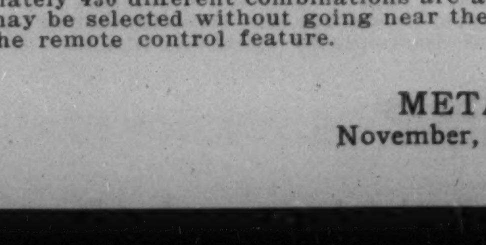
New Blowpipe Head



The Linde Air Products Company, New York, N. Y., has just announced a new welding head, known as the Multi-Flame Lindewelding Head, for use on W-17 or W-22 Oxweld blowpipes. The Lindeweld Process for pipe welding introduced about three years ago has been the means of greatly reducing pipe line installation costs, and the innovations incorporated in the new welding head will further reduce these costs by large amounts. The Multi-Flame Lindewelding Head consists of a special chromium-plated stem and tip, available in three sizes, their use depending upon the pipe size. Its radical departure from other blowpipe heads is the design of the tip to give three flames: a main welding flame and two smaller auxiliary flames, the latter so positioned as to preheat both edges of the vee ahead of the point of welding.

Savings of more than 25% in rod and gases and 33 1/3% or better in welding time are claimed with the new head employing the special manipulative technique recommended for its use.

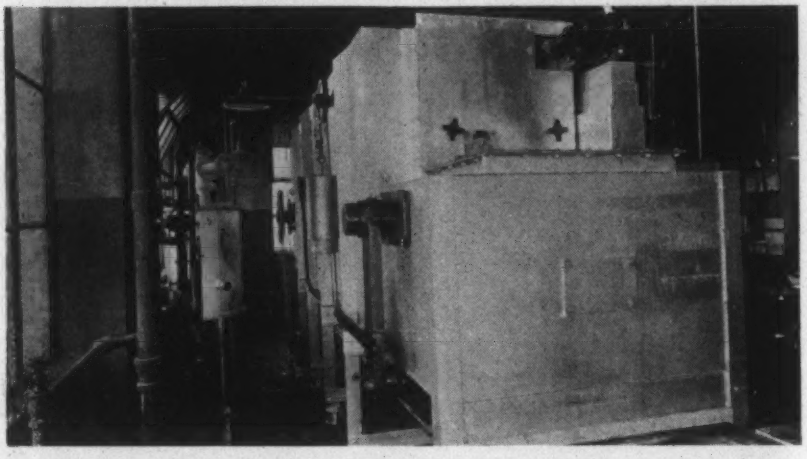
New Volt Amp Adjuster



Hobart Brothers Company, Troy, Ohio, announce their remote control of electric arc welding equipment. This new improvement illustrated gives the operator more than 140 combinations of voltage and welding current, no matter how far he is working away from the machine, for each of the machine ranges, therefore, approximately 430 different combinations are available, 1/3 of which may be selected without going near the machine when using the remote control feature.

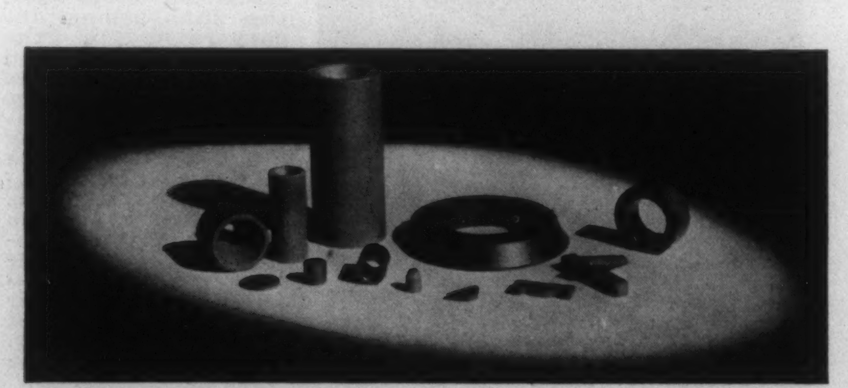
Continuous Scale Free Hardening Furnace

A special atmosphere, continuous chain belt conveyor furnace for the scale free hardening of miscellaneous small and medium size products has been developed by The Electric Furnace Company, Salem, Ohio. The material to be treated is fed onto a rugged, cast link belt conveyor, conveyed through the furnace in a special protective atmosphere and discharged through a sealed chute to quench. The material comes out absolutely free from scale. A combustion type generator is provided with the furnace for supplying the special protective atmosphere used in the equipment. This type of furnace may also be used for bright annealing, clean annealing and the brazing or joining of metal parts. The accompanying photograph shows the charging end of the furnace, the controlled atmosphere generator is shown in the rear.



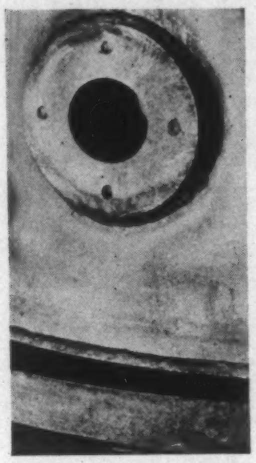
A New Hard Material

This new material, developed by the Norton Company, Worcester, Mass., chemically known as boron carbide, is so hard that it readily scratches and cuts the hardest of known synthetic materials which have previously existed. Boron carbide, which is unaffected by the strongest acids and alkalis, has compressive strength of 260,000 lbs./in.², coefficient of expansion approximately two-thirds that of steel, is little affected by temperature up to 1000° C., at which point the diamond burns completely, and it is lighter than aluminum. The new material has found an immediate use in the cutting and lapping of the new hard alloys known as cemented tungsten carbides. Experiments have shown boron carbide to be useful for many previously unsuspected purposes. The art of pressure blasting has always been carried on in industry with the use of metal nozzles to control the spray of sand or other abrasive against castings and metal surfaces of all kinds. The cleaning of public buildings, the preparation of metal surfaces of automobiles before painting and the engraving of marble monuments has been carried out for years with the aid of pressure blasting or as it is more commonly known, sandblasting. To a certain extent the application of hard abrasives to such cutting jobs has been impeded by the high rate of wear on the metal nozzle caused by the abrasive stream through it. It has been found that this new carbide is very much harder than the hardest of the old abrasives and that it can be molded into pressure blast nozzles which show many thousand times the wear resistance under blasting conditions of any metal material previously used for this purpose. In some cases the purchase of one nozzle will last the life of a sandblast machine where formerly the nozzles used were completely destroyed in 30 minutes. Because of the high intrinsic hardness of the product, its application to uses where gem materials have formerly been necessary was immediately tried. It has found application drawing fine wires and for extruding dies, showing almost unbelievably long life with some materials.



Wear resistant bearings of all kinds have been manufactured of the new product suitable for inclusion in such widely different uses as electric meters and high speed rotating spindles on grinding machines. Here the high polish and hardness of the boron carbide approaches that obtainable with the highest grade industrial diamonds. In a certain sense, therefore, boron carbide is a substantial attainment of industrial diamonds by synthetic means.

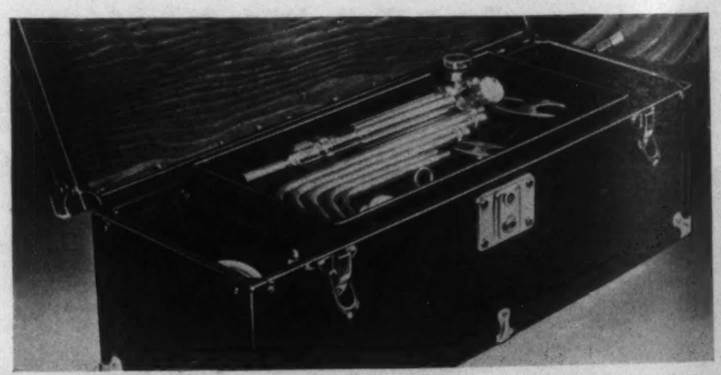
New Welding Electrode



A new heavily-coated arc-welding electrode, designated as G-E Type W-23, for the economical production of high-speed, high-quality welds in the flat position, has been announced by the General Electric Company. Type W-23 electrodes are suitable for either manual or automatic arc welding and will produce equally good results on either alternating or direct current. With the latter, reverse-polarity is used. The element of economy in the production of high-quality welds is provided by the ability of Type W-23 electrode to operate at higher speeds, in larger diameters (¼, 5/16, and ⅜ inch), and at higher current values than those commonly in use. Another economy-promoting characteristic is the fact that Type W-23 welds fuse uniformly with the side walls of the joint—thus saving the time and labor ordinarily spent in chipping out slag from pockets at the line of fusion. On most work, the production rate with Type W-23 is greater than with other heavily coated electrodes and two to three times the rate with bare or lightly fluxed electrodes. Welds made with the new electrode are smooth and of excellent appearance, and possess exceptional tensile strength, density, ductility, and resistance to impact and corrosion. Welds made with Type W-23 more than meet the requirements for Class I (A.S.M.E. Boiler Code) and E-10 (A. W. S. Tentative Filler Metal Specifications). This electrode has also been approved by the American Bureau of Shipping for Class I (E-10 A.W.S. Spec.) welding in the construction of hulls and machinery subject to classification by the Bureau.

New Oxyacetylene Outfit

To meet the need of steamfitters and plumbers for a reasonably priced outfit for the installation of Walseal Threadless Bronze Fittings by the Aircobraze process, Air Reduction Sales Company have developed the "Aircobraze Oxyacetylene Outfit." With this outfit hooked up to the gas cylinders, it is only necessary to slip the brass pipe into the Walseal fitting until it butts up against the shoulder and apply the Aircobraze process to the pipe and fittings until the white ring of Sil-Fos appears around the pipe—visible evidence that the joint has been made. These outfits will be distributed by the Walworth Company to the plumbing and heating trade. This same outfit is also entirely suitable for pipe welding.



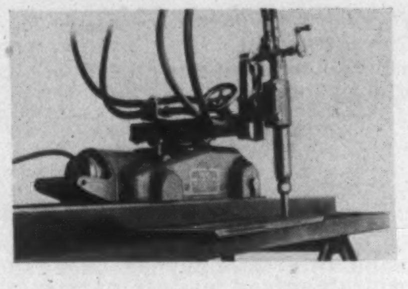
High Pressure Casting Method

Pressure Castings, Inc., Cleveland, announce the development of the hydraulic casting process. The pressure being hydraulically applied, it is claimed, permits such tremendous pressure as 3,000 to 17,000 lbs./in.² When the metal is inducted into the mold under such high pressure, the resultant casting becomes intensely dense, thoroughly and uniformly homogeneous from surface to surface, with an immense increase in tensile strength. Additional advantages claimed for the solid pressure method include the better handling of the molten metal throughout the process. The metal is kept plastic in a closed, non-oxidizing furnace. Its only contact is with a non-metallic holding pot. It is not subject to the contamination that results in the air casting process, where the metal at high temperature comes in direct continuous contact with the iron pot and gooseneck. Under those conditions the metal is certain to pick up many impurities while also being subject to oxidation.

In high pressure casting a charge of the molten metal is either automatically or manually picked up and placed into a cylinder in close proximity to the die. Here it comes into momentary contact with the cold ground surfaces of the cylinder and plunger head, this action chilling a thin protective shell on the metal. Almost simultaneously the plunger is actuated, which crushes this thin solidified shell and propels the metal under great pressure into the cavity of the die. As the plunger is moved by a hydraulic cylinder, a definite space of time is required for the actual injection of the metal. While this period of time is only a fraction of a second, it is long enough to allow for the complete scavaging of the air from the mold, thereby insuring the perfect solidity, homogenity and density of the resulting casting.

Cutting Machine

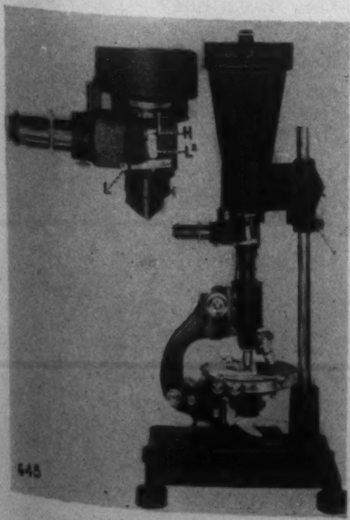
The Linde Air Products Company, New York, N. Y., has just announced a new addition to its large line of oxy-acetylene cutting machines, The Oxweld Monitor or CM-8 Cutting Machine. Every effort has been made to make the Monitor a perfect example of machine design. It is of extremely rugged construction, streamlined to facilitate both operation and maintenance. It is easily portable, and is adjustable through the entire range of oxy-acetylene cutting. All the working elements are enclosed in a double cover. The machine does automatic straight line cutting of practically unlimited length, straight bevel cutting, two bevels at a time if desired, plate edge preparation, circle or ring cutting of diameters up to 100 in. and the cutting of curved or irregular shapes. It should prove an indispensable tool for the metal industry. One blowpipe, the Oxweld C-7, is supplied as standard equipment, thus permitting cuts up to 12 in. The Oxweld C-22 Blowpipe may be substituted for heavier cutting and certain flame machining operations. Provision is made for the use of two blowpipes simultaneously. These can be mounted either on the same or opposite sides of the machine, and adjusted independently. The slide for the blowpipe holders is constructed so that it may be swung instantly into any horizontal position over a working arc of 250°. Protractor scales gage the tilting of the blowpipes in either direction parallel to the side of the machine through 90°, and up to 90° at right angles from the side. Special care has been given to speed control, and the sensitive indicators eliminate all guess work. Merely by setting the indicator and shifting the gear lever any speed may be instantly obtained within the range of 2 to 48 in. per min. The location of the speed regulator near the guiding handle of the machine makes it possible to alter the speed at any instant during cutting without stopping the work.



Two New Photomicrographic Cameras

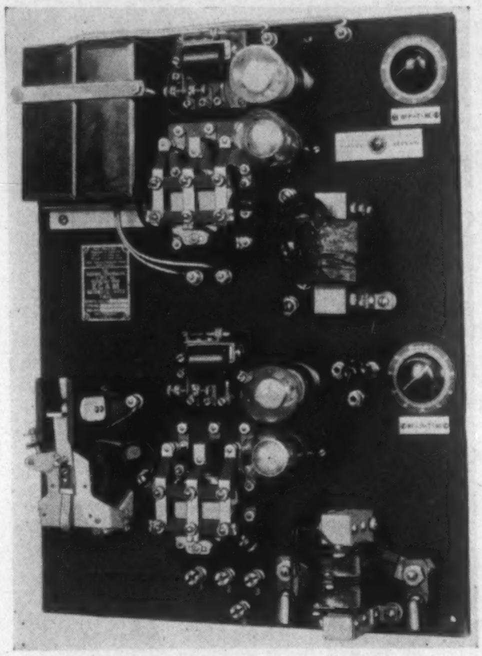
Two new cameras are announced by the Spencer Lens Company, Buffalo, N. Y. The No. 640, a 5" x 7" camera, is a well built outfit with a considerable bellows extension which is equally efficient in either the vertical or horizontal position. The camera is mounted on a base 16" x 12¼", with a rigid upright 1¼" in diameter, and 30" high. A short heavy arm revolves on the upright. At the end of this arm is hinged a long telescoping bar which supports the bellows and the plate holder frame. This may be lengthened and shortened with the bellows to give an extreme bellows length of 24" or a short bellows of 8". Both the plate holder frame and the support for the small end of the bellows move freely on the arm. The support at the front end of the bellows is also movable by means of a rack and pinion which is a great convenience in connecting and disconnecting the microscope from the camera, also for careful focusing when the micro-teleplat photographic lenses are used. An extension bar, which slides beneath the base of the camera, supports the plate holder frame through an adjustable support projecting downward from the middle of the lower side, when the camera is in the horizontal position. Aside from this, the telescoping bar is supported by an arm hinged to and extending from the base. This combination makes a very rigid support for the camera in the horizontal position.

The No. 645 camera was designed to be used with a standard microscope illuminant. It is primarily for the microscopist who is doing routine work and frequently wishes to make permanent photographic records of his observations. It is of substantial construction of the conventional type with solid base and rigid vertical supporting rod. The camera body, which is of metal, accommodates either 3¼" x 4¼" or 4" x 5" double plate holder as ordered. It also carries a side focusing the specimen on the plate from the side without change of position of the set-up. It is of fixed length. 250 mm. which is the correct projection distance to give the specimen precisely the same magnification on the photographic plate as is obtained visually. The camera body can be swung around the upright post from its position for photography, to an out of the way position for visual work. It is entirely supported by a collar which has a locating lug on it, so that it can be immediately returned to the optical axis for photography. This supporting collar can be adjusted vertically on the supporting rod to accommodate the camera to the different heights of microscopes.



Automatic Repeat Weld Timer

For use in connection with resistance welding machines in which the electrodes of the welder are air or motor-operated, The Electric Controller & Mfg. Company, Cleveland, Ohio, announce their automatic repeat weld timer. This timer is the same as the standard E. C. & M. automatic weld timer except that it has an additional timing circuit for governing the length of time the electrodes of the welding machine are separated to allow the work to be moved to the position where the next weld is desired. The "welding-period" provided by this timer varies in inverse proportion to the rate of current flow insuring the correct number of heat units are put into each weld, while the "off-time" or period the electrodes are apart, is a definite length of time which is adjustable. With the E. C. & M. automatic repeat weld timer, there are two separate electrical circuits easily adjustable and independent of each other. This means that it is possible with this timer to start in a "green" operator with the proper time interval to allow for shifting the work and as the operator becomes more expert, the "off-time" can be gradually shortened up in almost perceptible steps to compensate for the increasing efficiency of the operator.

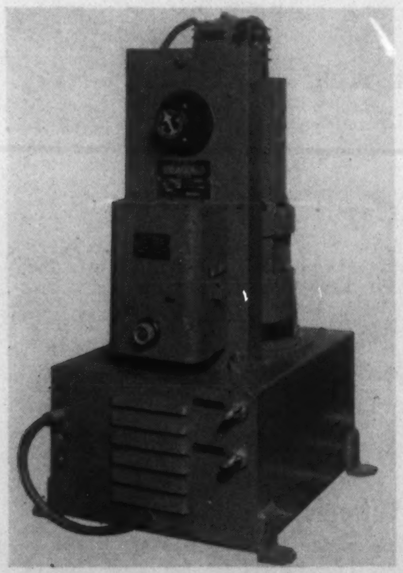


Aluminum Alloy De-Gaser

Foundry Services, Inc., New York, announce the Foseco aluminum de-gaser for aluminum alloys. It is claimed that the tensile strength is increased from 2000 to 5000 lbs./in.² and that the elongation is improved by 20 to 30%.

New 75 Ampere Welder

Demands for an arc welder which can be used on thin sheets, plates and shapes by garages, metal-working shops and industrial plants are met by a new small motor-generator unit announced by The Lincoln Electric Company, Cleveland, Ohio. This new welder can be supplied for use on any alternating current power line including 110 volt circuit. The makers claim this new welder, known as the SA 75, is the first unit ever built which will deliver as low as 20 amperes at the arc without the use of auxiliary devices. As a result of this, an entirely new field of application for arc welding is opened up. Repair shops will find many advantages in using the new welder. It provides the low uniform welding current needed for fender and body repairs and at the same time it can be used in repairing bumpers, frames and other heavier materials. Its advantages will be particularly appreciated in the repair of cracked water jackets or cylinder heads. As no preheating is necessary in making arc welded repairs, damaged cylinder heads can be repaired without removing the engine from the car. With former methods of welding used for this sort of work, it has been necessary to remove and completely dismantle the engine, because of the danger of damaging bearings and other parts due to necessity for preheating. Since it supplies a uniform current of proper characteristics for using electrodes as small as 1/16", this new welder can be employed by metal-working shops and industrial plants on materials as light as 24 gage. With the new welder it is possible to produce in light materials welds of the same uniformly high quality as that regularly obtained on heavier materials with the shielded arc process of welding.



Non-Ferrous Regenerators

Foundry Services, Inc., New York, have developed 3 regenerators claimed to eliminate gases, oxides and solid impurities, secure denser castings, reduce porosity losses and produce cleaner surfaces:

R6 for gun metal and bronzes.
R8 for yellow brass and phosphor bronze.
R5S for nickel alloys and pure copper.

MANUFACTURERS' LITERATURE

Note: (This department is conducted for the convenience of the readers of METALS & ALLOYS *desiring to add to their files copies of current literature issued by manufacturers. Any items desired can be secured free by applying direct to the issuing firms or in those cases where a number of items are wanted applications may be sent direct to this office. A coupon is provided on which the numbers of the items required can be listed.)*

"Simplified Arc Welding"

Pamphlet illustrating, describing and setting forth the advantages of this system of arc welding which is said to possess money saving possibilities on such work as maintenance, production, repairs, redesign, salvage and in the tool room. Hobart Brothers, Troy, Ohio. (483)

Inland Steel Sheet

Pamphlet containing data on this zinc coated alloy steel which is said to solve four difficult problems. Inland Steel, 38 S. Dearborn St., Chicago, Ill. (484)

Carbofrax Veneered Arches

Booklet No. 3 illustrates and describes "Carbofrax," the Carborundum Brand Silicon Carbide refractory. Typical installations illustrated. The Carborundum Company, Perth Amboy, N. J. (485)

New Method Annealing

Booklet illustrating and describing the new Bellis Lavite annealing method, which it is claimed makes substantial savings. Temperature curve and work program, power curves, shop power curve, furnace power curve, total power curve, also comparison of annealing costs charts. The Bellis Heat Treating Co., Branford, Conn. (486)

Murex Electrodes

Booklet illustrating and describing heavy mineral coated Murex electrodes. Metal & Thermit Corporation, 120 Broadway, New York, N. Y. (487)

Bethlehem Castings

Leaflet describing these centrifugal brass and bronze castings for ship construction, paper and pulp mill machinery, chemical plant equipment, textile machinery, hydraulic equipment, pump and press liners, pneumatic tubes, driers, mining machinery, coke work equipment. Bethlehem Steel Company, Bethlehem, Pa. (488)

Carbofrax

Leaflet illustrating Carbofrax standard brick shapes and plain tile. Tables of sizes. The Carborundum Company, Perth Amboy, N. J. (489)

Weld It Well!

Attractive booklet Bulletin No. HW-3 illustrating and describing the P. & H. "Hansen" Arc Welder, both portable and stationary types. Harnischfeger Corp., Milwaukee, Wis. (490)

Krokoloy

Leaflet setting forth application and performance of Krokoloy chrome cobalt alloy tool steel (cast to shape) for the pattern department, for the heat treating department and for the finishing department. Detroit Alloy Steel Co., Foot of Iron Street, Detroit, Mich. (491)

Standard Wire Drawing Benches

Booklet illustrating and describing coil clutch block type without draw-out motion. Tables of sizes and dimensions. The Waterbury Farrell Foundry & Machine Co., Waterbury, Conn. (492)

Vulcan Wheels

Attractive booklet illustrating and describing this modern metal wheel claimed by the company to be the lightest, simplest and strongest metal wheel, single or dual, for trucks, busses and trailers. Vulcan Wheels Inc., Avenue L and Thornton Street, Newark, N. J. (493)

Shear Knife Hand Book

Attractive hand book containing a wealth of information on the subject indicated. Illustrations, tables of dimensions, grinding instructions, etc. Heppenstall Company, Pittsburgh, Pa. (494)

Lincoln "Shield Arc" Welder

Specification Bulletin No. 304 contains general specifications, dimension drawing, and photographs of welder. The Lincoln Electric Company, Cleveland, Ohio. (495)

Turbo-Compressors

Booklet illustrating and describing turbo-compressors for oil and gas-fired furnaces, ovens and foundry cupolas. Sectional view of Spencer turbo-compressors, pressure tables, performance curves, etc. The Spencer Turbine Co., Hartford, Conn. (496)

Entrained Combustion

Attractive booklet descriptive of the Mettler entrained combustion gas burner used successfully in large hotels, hospitals, glass manufacturing plants and many other great plants. Illustrations of actual installations. Tables, detail drawings etc. Lee B. Mettler Co., 405 S. Main St., Los Angeles, Calif. (497)

New American Bell-Type Retort Furnace

Pamphlet containing shop equipment news. Diagrams. Illustrations. American Gas Furnace Co., Elizabeth, N. J. (498)

U S S High-Tensile Steels

Pamphlet describing high tensile steels developed to meet the need of the transportation industry. Tables of chemical and physical properties, shop practice, summary of advantages. United States Steel Corporation Subsidiaries, Frick Bldg., Pittsburgh, Pa. (499)

Eastern Steel Castings

Pamphlet descriptive of electric, open hearth and alloy steel castings up to 10,000 pounds. Illustrated. Eastern Steel Castings, Avenue L and Edward Street, Newark, N. J. (500)

J & L Steel

Booklet descriptive of J & L improved Bessemer screw steel in hot rolled bars, cold finished bars, and drawn wire. Table of cold drawn physical properties, chemical specifications, representative tests on improved practice, micrographs of Bessemer screw steel. Jones & Laughlin Steel Corporation, Pittsburgh, Pa. (501)

Everdur Tanks

Bulletin E-7 sets forth capacities and dimensions, metal thickness required to meet various pressures. Also formulae and comparative physical data. The American Brass Co., 25 Broadway, New York, N. Y. (502)

Misco Chain

Bulletin No. 1-A sets forth data on this chain for use at high temperature. Illustrations. The Michigan Steel Casting Co., Detroit, Michigan. (503)

"Blueclad" Fittings

Bulletin No. 2 descriptive of "Blueclad" wire rope clips and thimbles, contains many illustrations, tables, etc. John A. Roebling's Sons Co., Trenton, N. J. (504)

The 7 Points of "Certain Curtain" Furnace Atmosphere Control

Bulletin No. 21 contains interesting data on the subject indicated. Micrographs, illustrations, etc. C. I. Hayes, Inc., 129 Baker Street, Providence, R. I. (505)

Bethlehem Steel

Bulletin No. 130-A contains data on Bethlehem heat-treated alloy steel bolts, studs and nuts, for high-temperature, high pressure service. Illustrations, charts, tables are included. Bethlehem Steel Co., Bethlehem, Pa. (506)

USL Electric Arc Welders

Bulletins in looseleaf binder setting forth data on this arc welder. Many illustrations, charts, detail drawings and specifications are included. USL Battery Corp., Niagara Falls, N. Y. (507)

Thermit Welding

Booklet descriptive of the Thermit welding process for railroads and street railways, for marine work, for reclaiming broken machine parts, and making permanent repairs to steel mill equipment. Illustrations. Metal & Thermit Corp., 120 Broadway, New York, N. Y. (508)

Rego Welding and Cutting Apparatus

Looseleaf catalog containing data on the subject indicated, profusely illustrated, The Bastian-Blessing Company, 240 East Ontario Street, Chicago, Ill. (509)

Welding Rod and Equipment

Booklet containing data on oxy-acetylene welding and cutting equipment. Illustrated. Joseph T. Ryerson & Son, Inc., Chicago, Ill. (510)

Pressure Regulators and Regulation Problems

Attractive booklet that will prove of great interest to all industries that require accurate, uniform pressure control and the close regulation of oxygen, acetylene and other gas pressures. Air Reduction Sales Co., 60 East 42nd Street, New York, N. Y. (511)

The Fiftieth Year

An attractive book, just published, in commemoration of the company's golden anniversary. Beautifully bound in gold and purple and profusely illustrated throughout its 84 pages, this book is one of the most interesting and impressive of its kind to appear in recent years. It tells the story of an organization built in the American tradition—its small beginning—its early struggles against all manner of adversity—its pioneering of many types of equipment which play such an important part in the high-geared industry of today. A valuable addition to any library. Executives desiring copies will receive them by addressing a request on company stationery to the Harnischfeger Corporation, Milwaukee, Wis. (512)

Revenue from Electric Metal

Booklet, the contents of which is in the nature of a discussion for utility men. Profusely illustrated and contains many valuable data. Detroit Electric Furnace Co., Detroit, Mich. (513)

Ladle Sparks

Interesting little booklet (Vol. 1., No. 4) containing much interesting material on Sivyer steel. Illustrations, micrographs, tables, charts, etc. Sivyer Steel Casting Co., Milwaukee, Wis. (514)

Nozzle and Stopper Rod Assemblies

Reprint of an interesting article by H. V. Beasley from *Blast Furnace & Steel Plant.* Vesuvius Crucible Co., Swissvale, Pa. (515)

New Controlled-Atmosphere Electric Furnace Bulletin

A recently published 12 page bulletin GEA-1924, illustrates and describes General Electric controlled atmosphere electric furnaces and their auxiliaries, and discusses some of their more important applications. General Electric Company, Schenectady, N. Y. (516)

A Valuable Steel Service

Leaflet descriptive of Union Drawn's field service. Union Drawn Steel Co., Massillon, Ohio. (517)

Ampco Metal

1934 Engineering Data Sheet No. 9 containing data on this subject. Ampco Metal, Inc., Milwaukee, Wis. (518)

Thumbs Down on Rust

Bulletin No. ADV. 132 explaining three reasons for the high rust-resistance of Toncan Iron and illustrating a number of typical installations of this long-lasting sheet iron. Republic Steel Corp., Massillon, Ohio. (519)

Air Draw Furnaces

New Bulletin HD-934 describing line of box type air draw furnaces with motor driven fan. Hevi Duty Electric Co., Milwaukee, Wis. (520)

SC Special Furnaces in the Steel Industry

Leaflet illustrating and describing burner equipment, standard furnaces and continuous furnaces for industry, annealing, carburizing, hardening, normalizing, nitriding, forging, heating controlled atmosphere furnaces. Surface Combustion Corp., Toledo, Ohio. (521)

The American Airless Wheelabrator

Circular descriptive of an entirely new method of abrasive cleaning. American Foundry Equipment Co., Mishawaka, Indiana. (522)

Electrunite Mechanical Tubing

Folder descriptive of this tubing. Steel and Tubes, Inc., Cleveland, Ohio. (523)

Bellis Lavite

Catalog containing a wealth of information on this heating medium. Illustrations, tables, charts, specifications are included. The Bellis Heat Treating Co., Branford, Conn. (524)

UNA Welding Rods

Bulletin No. 144 is descriptive of these welding rods for high speed, automatic high strength, high ductility, protected arc, hard surface, manganese, stainless steel, copper-copper, copper-steel. UNA Welding, Inc., Cleveland, Ohio. (525)

Industrial Instruments

Bulletin No. 420 descriptive of these instruments for indicating, recording and controlling. Profusely illustrated. The Bristol Co., Waterbury, Conn. (526)

Grinding Wheels for Every Purpose

Booklet illustrating and describing the subject indicated. Macklin Co., Jackson, Mich. (527)

Copperoid Steel Sheets

Leaflet illustrating and describing subject indicated. The Youngstown Sheet & Tube Co., Youngstown, Ohio. (528)

TAM Products

Leaflet descriptive of TAM metallurgical alloys. The Titanium Alloy Mfg. Co. (Metallurgical Alloy Division), Niagara Falls, N. Y. (529)

Stuart's Thred-Kut

Leaflet descriptive of this concentrate cutting oil. D. A. Stuart & Co., 2727 South Troy St., Chicago, Ill. (530)

Bethlehem Tool Steel

A group of four interesting little booklets has been issued on the subject indicated covering extra special high speed tool steel, hollow drill steel, die and tool steel, tool room oil hardening tool steel and No. 71 alloy tool steel. Bethlehem Steel Company, Bethlehem, Pa. (531)

Dowmetal

Data book, new 1934 addition, in which is recorded significant accomplishments since the publication of the last data book, particularly in those sections dealing with "Available Forms" and "Shop Practice." Profusely illustrated and containing data on properties, shop practice, specifications and availability. A valuable addition to your library. The Dow Chemical Company, Midland, Mich. (532)

Perliton Liquid Carburizer

New Booklet containing graphs and microphotographs, illustrating the results obtained with this carburizer. The data set forth in this book are claimed by the manufacturer to be the results of actual tests in the field and not merely laboratory experiments. E. F. Houghton & Co., 240 West Somerset Street, Philadelphia, Pa. (533)

Heat and Corrosion Resistant Alloys

New bulletin on the subject indicated. Illustrations of commercially used materials and the applications stated in this bulletin are claimed by the manufacturer to be the result of long and proven practice and cover the equipment ordinarily employed in the metallurgical and engineering fields, such as retorts, containers and equipment for carburizing and chemical work, food machinery of all types, oil still and processing equipment, heat and corrosion resistant castings generally. Lists a number of alloys, stating nickel and chromium content for each grade, and indicating the general field of application. Michiana Products Corp. (Alloy Div.) Michigan City, Indiana. (534)

METALS & ALLOYS, 330 West 42nd St., New York, N. Y.

I should like a copy of each piece of Manufacturers' Literature listed below.

....

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Position .... Firm ....

Street and Number ....

City .... State ....

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